

# NAVAL POSTGRADUATE SCHOOL

## Monterey, California



### THESIS

**A COMPARISON OF AN ALTERNATIVE INVENTORY  
CONTROL CONCEPT WITH THE NAVY'S EXISTING  
WHOLESALE INVENTORY CONTROL PROCEDURES  
FOR REPAIRABLES**

by

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September 1998

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WITH THE NAVY'S EXISTING WHOLESALE INVENTORY CONTROL  
PROCEDURES FOR REPAIRABLES**

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Submitted in partial fulfillment of the  
requirements for the degree of

**MASTER OF SCIENCE IN OPERATIONS RESEARCH**

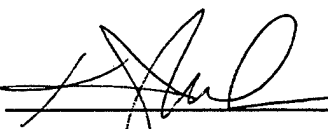
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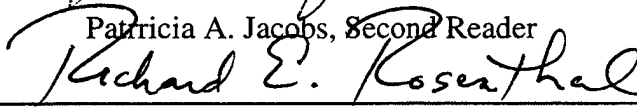
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## ABSTRACT

The Director of Planning and Operations Research Department, Naval Inventory Control Point (NAVICP) Code M041, requested a study to compare the performance of two sets of inventory control procedures for managing high-cost repairable items. One of these sets is embedded in the Navy's existing wholesale inventory control system. The procedures of this set characterize a periodic review process, which calculates four decision variables in order to manage Navy inventories. These variables represent how much to order, how much to repair, when to order, and when to repair. The other set of procedures are adapted from a commercial software package called Bandwidth Management developed by Stewart-Frazier Tools Inc. Two versions of these latter procedures are modeled in this thesis. These procedures characterize a periodic review process, which calculates three decision variables. These variables represent how much to deliver, how much to repair, and when to repair. This thesis uses simulation to model the two sets of procedures and to compare their performance with respect to three formal measures of effectiveness adopted by NAVICP: Supply Material Availability (SMA), Average Delay for a Delayed Requisition (ADDR), and Average Monthly Investment Level (AMIL). The comparison results of the thesis indicate that the existing Navy inventory procedures generate better performance in all three formal measures of effectiveness.

## **THESIS DISCLAIMER**

The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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## EXECUTIVE SUMMARY

The Naval Inventory Control Point (NAVICP) is responsible for the procurement, repair, and management of over 375,000 spare parts. These parts are required to support the operation of ships, submarines, Naval aircraft, maintenance activities, all associated weapon systems and related test equipment. NAVICP uses the Uniform Inventory Control Program (UICP) to implement the Navy's wholesale repairable inventory control procedures. UICP characterizes a periodic review inventory process that calculates four decision variables in order for the Item Managers to manage Navy inventories. These variables represent when to buy, how much to buy, when to ship failed items to the repair facility, and how many to ship.

The Director of Planning and Operations Research Department, NAVICP Code M041, requested a study to examine the performance benefits of a set of proposed inventory control procedures for managing high-cost repairable items. These procedures are based on techniques implemented in a commercial software package known as Bandwidth Management (Stewart and Frazier, 1996). Because Bandwidth Management does not explicitly handle repairable items, this thesis proposes two sets of procedures resembling the Bandwidth Management concept of regular monthly deliveries and a periodic review process. It incorporates the same UICP procedures for the repair process. These two sets of procedures calculate three decision variables that represent how much to deliver each month, how much to repair, and when to repair.

Monte Carlo simulation is used to compare the performance of the three sets of inventory control procedures. The simulations are referred to as *UICP*, *BAND* and

**THIRD.** The initial inputs are taken from historical data of 240 high-cost items specified by NAVICP Code M051.

Performance of each simulation is determined by calculating three formal measures of effectiveness (MOE's) adopted by NAVICP: Supply Material Availability (SMA), Average Delay for Delayed Requisition (ADDR), and Average Monthly Investment Level (AMIL). SMA is the percentage of demands that is filled immediately; ADDR is the average number of days a demand remains unfilled; and AMIL is the holding cost of inventory and is calculated as the product of an item's replacement cost, holding cost rate, and average monthly inventory level.

The simulation results clearly indicate that the Navy's existing inventory procedures are the more favorable set of procedures to manage the Navy's high-cost wholesale repairable items. UICP exceeded both **BAND** and **THIRD** in each of the three MOEs.

Sensitivity analysis is performed to determine whether dividing the 240 items based on replacement cost would produce a category where **BAND** or **THIRD** would perform more favorably. These results proved negative. It is recommended that the Navy continue to use its existing inventory control procedures to manage its wholesale inventory.



## **I. INTRODUCTION**

### **A. BACKGROUND**

On October 2, 1995, the Navy's two Inventory Control Points, the Ship's Parts Control Center (SPCC) in Mechanicsburg, PA. and Aviation Support Office (ASO) in Philadelphia, PA combined to form a single command called the Naval Inventory Control Point (NAVICP).

Currently, NAVICP Mechanicsburg (NAVICP-Mech) is responsible for the procurement, repair, and management of over 233,000 spare parts for ships and submarines, and their associated systems. NAVICP Philadelphia (NAVICP-Phil) is responsible for the procurement, repair, and management of over 142,000 spare components applicable to Naval aircraft, aircraft weapon systems and related test equipment; see NAVICP ltr (1997).

Inventory management in the United States Navy is constantly changing and has become a very complex process over the past 20 years. Technology has increased at such a rapid pace in the design of major weapon systems that the required logistical support has become much more critical. Requirements determination is one of the most important components of logistical support. Requirements determination includes the process of reviewing inventory requirements, anticipating available assets, and deciding how much to procure and repair based on demand, system criticality, and available funding. One type of item is one that can be repaired. These items are called repairables.

Early inventory control procedures were developed for repairables and proved to be more than adequate to manage inventory in the early 1980's when funding was not a major issue. However, in recent times, funding has been greatly reduced. As a result, a

more efficient inventory control procedure is desired. The new procedure must be capable of improving customer service at a lower investment cost.

In search of better customer service at lower investment cost, the Director of the Planning and Operations Research Department, NAVICP Code M041, requested a study to compare performance and investment costs between the current NAVICP repairable inventory control system and a system similar to that of Bandwidth Management (Stewart and Frazier, 1996). This thesis responds to that request.

Inventory control systems use procedures that are based on inventory management models. Early inventory management models assume demand is constant and were developed based on the stipulation that stockouts were not allowed. After World War II, G. Hadley of the University of Chicago and T.M. Whitin of the University of California, Berkeley argued that demand was not constant but instead, a random variable. Hadley and Whitin (1963) developed an inventory model based on the concept that demand was a stochastic process and the average rate of demand remained constant over time. Their research and development helped create the principal policy for the current DoD instructions concerning procurement cycles and safety levels of stock for consumable items.

The system of computer files, programs, and reports used by NAVICP-Mech and NAVICP-Phil for inventory management is known as the Uniform Inventory Control Program (UICP). UICP was developed in 1965 to provide a standardized system for both commands to use. Fleet Material Support Office (FMSO) under Naval Supply Systems Command (NAVSUP) is responsible for system design, maintenance, ADP analysis, programming, and documentation of the UICP system (DoN, 1991).

## **B. OBJECTIVE**

The primary purpose for this research is to compare the current UICP procedures to proposed procedures based on those implemented in a commercial product known as Bandwidth Management (Stewart and Frazier, 1996). Monte Carlo simulation is used to compare the two procedures. The simulations use data from 240 high-cost repairables identified by Mr. Bill Howells, Deputy Director NAVICP Code M051. These items represent twenty percent of all the Depot Level Repairables (DLR's) within Code 051 and account for eighty percent of their total investment. A time event simulation has been written for each process and the associated code is available from the author at NAVICP Code M041.D. The simulations are referred to as *UICP* and *BAND*.

This thesis determines which inventory control system is more efficient and more effective for these items. The systems are evaluated in terms of three formal measures of effectiveness (MOE's) adopted by NAVICP: Supply Material Availability (SMA), Average Delay for Delayed Requisitions (ADDR), and Average Monthly Investment Level (AMIL).

The objectives of this thesis are as follows:

1. Develop two simulation models, one to simulate the NAVICP process for repairable items and one to simulate the Bandwidth process for repairable items;
2. Compare performance between the two processes; and
3. Determine which process provides better inventory control for high-cost repairables.

## **C. SCOPE**

Direct comparison of the two processes` using historical performance data is difficult. The main reason for this difficulty is that the inventory control process is

influenced by external factors. For example, assets offloaded from decommissioned ships are returned to the wholesale system, increasing inventory levels to a point that surpasses the maximum limits. Assets removed from active ships due to aggressive retail inventory reduction projects also increase inventory levels. These sources of external adjustments render the data from the inventory control unsuitable to compare inventory control procedures.

The NAVICP process deals with a number of variables. Demand for asset items occur at random times and are either serviced immediately by shipping a replacement from stock or by creating a backorder if there is no item in stock. This demand may or may not be accompanied by the failed component (carcass). This carcass can either be repaired or replaced. Carcasses are placed in storage. They remain in storage until sent to a repair facility. Not all carcasses are capable of being repaired, but those that are repaired, return to wholesale stock at a fixed time later. The inventory control system has policies for deciding when and how many new material assets to order as well as when and how many carcasses to send to repair. Maher (1993) details these policies.

The Bandwidth Management process operates quite differently. It was designed solely for items that are not repairable. At the beginning, a fixed number of new assets are ordered for regular (monthly) delivery from a contractor. As time passes, the quantity in stock will vary because of variability in the demand process. It may occur that stock levels become either excessively high or dangerously low. The model is designed to “flag” these conditions through a set of control bands. If the forecasted stock levels exceed either the upper or lower band, the fixed replenishment quantity is recalculated.

Simulation is used to compare the two systems. In this way, the comparison of the two processes can be executed using a common random number stream, which allows both systems to operate with the exact same demand pattern. The problems associated with the real data are circumvented using simulation. Simulation also allows a provision to utilize the repair facility process in the monthly forecasting of stock levels for the **BAND** system. Both simulations are written using the JAVA programming language.

The comparison of both processes is made from a summary of the results of all 240 items from the simulations, and also by means of sensitivity analysis based upon the cost to replace each of the 240 items. This activity leads to consideration of an adaptation of **BAND** called **THIRD** that utilizes additional procurements to fill existing backorders. The summary results of **THIRD** are compared to **UICP**.

#### **D. ORGANIZATION**

Chapter II discusses the two inventory control processes. Chapters III and IV describe the **UICP** and **BAND** simulations respectively. These chapters discuss the purpose of each simulation, the assumptions made, and the structure and design of each. Chapter V describes the results from both simulations and the analysis of those results and introduces **THIRD**. All MOE's are compared and critical analyses are performed to determine which inventory process is more efficient and effective. Chapter VI summarizes the thesis research, identifies the better procedure, offers recommendations to the NAVICP, and discusses possible further work suggested as a result of this study.



## II. THE INVENTORY CONTROL PROCESSES

It is important to understand the two wholesale repairable inventory control procedures being compared in this thesis and the concepts on which they are based. This chapter discusses the current NAVICP procedures and the proposed Bandwidth procedures. The final section in the chapter discusses discrete event simulation implemented in JAVA.

The two inventory control procedures are compared based on three measures of effectiveness (MOE's) for each item. The measures are defined as follows:

$$\begin{array}{lll} \text{SMA:} & \text{The percentage of demands that could be filled immediately.} & \\ \text{SMA} & = & \frac{\text{(Number of First Time Issues)}}{\text{(Number of Total Demands)}} \quad (1) \end{array}$$

$$\begin{array}{lll} \text{ADDR:} & \text{The average number of days a demand remains unfilled.} & \\ \text{ADDR} & = & \frac{\text{(Total Waiting Time Of All Backorders)}}{\text{(Total Number of Backorders)}} \quad (2) \end{array}$$

$$\begin{array}{lll} \text{AMIL:} & \text{The cost associated with holding inventory in stock} & \\ \text{AMIL} & = & \text{The product of the cost to replace the item, the variable holding rate (I), and the average monthly inventory level.} \quad (3) \end{array}$$

*First Time Issues* refer to the immediate satisfaction of a demand request. *Total Demands* refer to the total number of demands that occur during the entire period of study. *Total Time of All Backorders* is the cumulative sum of waiting times in backorder for each demand placed in backorder status during the entire period of study. *Total Number of Backorders* is the total number of demands that were placed in backorder status during the entire period of study. The variable holding rate (I) sums the relative costs associated with capital, obsolescence, and storage. This rate is often expressed as a fraction or percentage of unit cost per year, i.e., the cost of holding one-dollar's worth of material in inventory for one year (Robillard 1994). For repairable items, NAVICP uses

the values 0.10 for capital (time preference), 0.10 for obsolescence, and 0.01 for storage costs.

It is possible that a failed item does not accompany the demand for a replacement item. The probability that a failed item, or carcass, will accompany the demand is referred to as the Carcass Return Rate (CRR) (Baker 1994). Additionally, the repairing facility will assess each item received and determine if it is capable of repair. The probability of repair for these items is referred to as the Repair Survival Rate (RSR).

An attrition is said to have occurred either when a failed item is not returned to the Item Manager (IM), or is assessed as not capable of repair by the repair facility. A procurement action is required to replace attritions in order to maintain the required inventory level.

When an item fails, a demand for a replacement item is generated. The failed item, if returned, is shipped back to the IM for repair or condemnation. The beginning of the repair cycle occurs when the failed items are received by the repairing facility. The cycle ends after the items are repaired by the repair facility and returned to the supply system as a Ready For Issue (RFI) asset. This period of time is referred to as the Repair Turnaround Time (RTAT) and is treated in this thesis as deterministic.

#### **A. NAVICP PROCEDURE**

The current wholesale repairable inventory control procedures are implemented in the Uniform Inventory Control Program (UICP). The purpose of this program is to determine how many new assets to buy, when to buy them, how many Not-Ready-For-Issue (NRFI) items to repair, and when to repair them. The program minimizes the annual total variable costs (Robillard, 1994).

The procedures in the UICP program are based on a periodic review inventory model that forecasts demand (D) for the upcoming quarter and computes associated levels based on that forecast. The mathematical derivations for the variables associated with the procurement and repair processes are discussed in detail in Maher (1993).

## 1. Procurement Process

A procurement decision for a particular item is based on three decision variables: Reorder Level (R), Order Quantity (Q), and Inventory Position (IP).

$$R = \text{Expected number of demands for the item a NAVICP defined "average acquisition time" plus a safety level} \quad (4)$$

$$Q = \text{Order quantity for the quarter} \quad (5)$$

$$IP = \text{On Hand} + \text{On Order} + (\text{NRFI carcasses} * \text{RSR}) - \text{Backorders} \quad (6)$$

where

<i>On Hand</i>	=	<i>current number of RFI items in inventory</i>
<i>On Order</i>	=	<i>number of items on order due to be delivered within a procurement lead time.</i>
<i>NRFI Assets</i>	=	<i>total number of Not Ready for Issue (NRFI) carcasses waiting at the holding facility for repair plus the number of those NRFI carcasses currently being repaired by the repair facility.</i>
<i>RSR</i>	=	<i>probability that a NRFI carcass can be repaired by the repair facility. Referred to as Repair Survival Rate.</i>
<i>Backorders</i>	=	<i>the number of backorders for the item that exist.</i>

The *safety level* is an additional level of stock used to reduce the probability of a stockout. Procurement lead time (L) or PCLT is the time interval beginning with the placement of an order by the IM and ending when that order arrives and is placed in wholesale stock. The IP is checked monthly and a procurement action is initiated if the IP falls below R.

## 2. Repair Process

A repair decision for an item is based on the following variables: Repair Level ( $R_2$ ) and Available Assets (AA). The repair decision sends a number of failed items from the holding facility to the repair facility.

$$R_2 = \text{Expected number of demands during a repair time (RTAT)} \\ \text{plus the safety level} \quad (7)$$

$$AA = \text{On Hand} + \text{Orders Due In} + \text{Repairs Due In} - \text{Backorders} \quad (8)$$

where

$$\begin{aligned} \text{On Hand} &= \text{current number of RFI items in inventory} \\ \text{Orders Due In} &= \text{number of items on order which are due} \\ &\quad \text{to be available within an RTAT.} \\ \text{Repairs Due In} &= \text{number of NRFI carcasses currently being} \\ &\quad \text{repaired by the repair facility due to be available} \\ &\quad \text{within an RTAT.} \\ \text{Backorders} &= \text{the number of backorders for the item that exist.} \end{aligned}$$

Each time a carcass accompanies a demand for its replacement, the carcass queue is increased by one. A value for AA is computed semi-monthly and a repair action is initiated if AA falls below  $R_2$ . The deficit is shipped (inducted) immediately to the appropriate repair facility. These carcasses are repaired and returned an RTAT later.

### B. BANDWIDTH PROCEDURE

The proposed wholesale repairable inventory control procedure is based on a procedure implemented in a commercial product known as Bandwidth Management (Stewart and Frazier, 1996). The proposed procedure is for items that are not repairable. It is a monthly review, periodic delivery inventory system. It determines a fixed monthly procurement quantity to be delivered by the contractor and establishes a control band based on historical demand data. Intervention by the IM is not required unless the

cumulative demand observations fall outside the designated upper or lower bounds of the control band.

## 1. Procurement Process

In the Bandwidth process, R, Q, and IP are not utilized and hence not calculated. Instead, a monthly delivery quantity (DELQTY) is computed as the product of the monthly forecast demand (D) and the wearout rate (W):

$$DELQTY = DW \quad (9)$$

where

$D$  = Monthly Forecast Demand

$W = 1 - CRR \cdot RSR$

where

$CRR$  = probability that a failed item (carcass) is delivered to a holding location. Referred to as Carcass Return Rate.

$RSR$  = probability that a NRFI carcass can be repaired by the repair facility. Referred to as Repair Survival Rate.

## 2. Repair Process

The repair decision in the Bandwidth process is conceptually the same as the UICP process. However, repair level (REPAIRLEVEL) and available assets (ASSETS) are computed differently. Instead of calculating the repair level based on demands during repair turnaround time, it is calculated based on the number of carcasses that can be returned from the repair facility during the upcoming month plus a safety level. The safety level is computed as twice the square root of the expected number of regenerated items that can be returned from the repair facility during the upcoming month. The REPAIRLEVEL is calculated as the sum of the mean and the safety level.

$$REPAIRLEVEL = \text{Expected Number of Regenerated Items} + \text{Safety Level} \quad (10)$$

where

$$\text{Expected Number of Regenerated Items} = D \cdot CRR \cdot RSR$$

$$\text{Safety Level} = 2\sqrt{\text{Expected Number of Regenerated Items}}$$

where

$$\begin{aligned} D &= \text{Monthly Forecast Demand} \\ CRR &= \text{probability that the failed item (carcass) will accompany a demand. Referred to as Carcass Return Rate.} \\ RSR &= \text{probability that a NRFI carcass can be repaired by the repair facility. Referred to as Repair Survival Rate.} \end{aligned}$$

Available assets are computed in a similar manner as in **UICP**. The quantity DELQTY is used in place of order quantity.

$$ASSETS = \text{On Hand} + \text{DELQTY} + \text{RFI DUE IN} - \text{Backorders} \quad (11)$$

where

$$\begin{aligned} \text{On Hand} &= \text{current number of RFI items in inventory} \\ \text{DELQTY} &= \text{monthly number of items delivered.} \\ \text{RFI DUE IN} &= \text{number of NRFI carcasses currently being repaired by the repair facility due to be available within the upcoming month.} \\ \text{Backorders} &= \text{the number of backorders for the item that exist.} \end{aligned}$$

As with the Navy's model, the carcass queue is increased by one if a carcass accompanies a demand. Additionally, ASSETS is calculated twice a month. If ASSETS falls below REPAIRLEVEL, then the difference is inducted immediately to repair and returned as wholesale stock in a time period RTAT later.

### C. DISCRETE EVENT SIMULATION

To analyze the performance of both the NAVICP process and the Bandwidth process, the author develops a time event simulation program for each. The NAVICP simulation is referred to as **UICP**, and the Bandwidth simulation is referred to as **BAND**. Both simulations are written using the JAVA programming language. Both models utilize the program SIMKIT, developed by Professor Arnold Buss and LT Kirk Stork at the Naval Postgraduate School (Buss and Stork, 1997). The simulation technique is

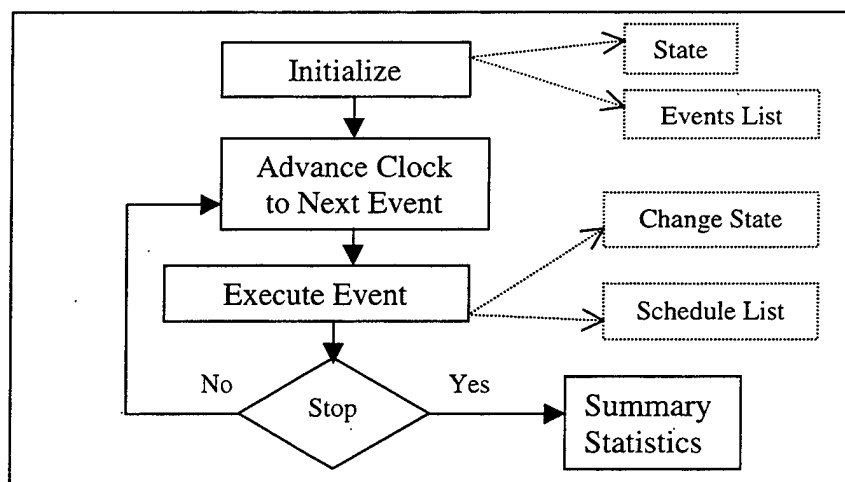
chosen since it is the most economic and realistic way to represent an inventory process and analyze its performance over a period of time, given a specific demand stream, certain input variables, assumptions and constraints. Simulation also allows the user to specify several system parameters and profiles.

Both simulations model the inventory management of a repairable item for 660 months. Demand for an item is generated in the following manner. The monthly mean and standard deviation for each item are computed from 60 months of historical observations. Display of the historical moments appears in Appendix A.

The monthly demands for an item are simulated as follows: The first step is to generate demands for each month. The number of demands in each month are assumed to be independent and identically distributed. If the historical mean monthly demand for the item is less than one-third, then the number of demands in a month is modeled as independent Poisson random variables with the mean being the historical monthly mean. If the historical monthly mean is greater than or equal to one-third, then the number of demands in a month is drawn from a normal distribution using the historical mean and standard deviation. If the generated normal random number is negative, the demand is set equal to zero. If it is positive, the closest integer to the number is taken as the number of demands. To validate the procedure, the monthly mean and standard deviation of the simulated demands is computed for each item over 600 months. Ten replications are run for each item and the mean of the monthly means and the mean of the standard deviations is computed. The results for each item are compared to the monthly mean and standard deviation of the historical data for the same corresponding item. Appendix B illustrates

the strong correlation between the simulated means and historical means, as well as the strong correlation between the simulated and historical standard deviation.

A simulation is implemented in the programming language JAVA. The simulation operates from a master appointment list of scheduled events referred to as the “event list.” It is called an event list because at any given time, it contains all events, which have been scheduled, and the times they are to be executed. Once the simulation starts, the simulation time will advance to the next scheduled event on the list. Occasionally, some future events are inserted into the list as a result of the simulation. The process continues until the simulation time reaches the finish time specified by the user. A general flow chart summarizing this process is illustrated in Figure 1.



**Figure 1. Main Event-Scheduling Algorithm**

### III. UICP SIMULATION

The first part of this chapter discusses the *UICP* simulation and its assumptions, followed by the structure and design of the simulation.

#### A. DISCUSSION

The initial parameters provided to *UICP* by the user are listed in Appendix C, together with a definition for each.

As discussed in Chapter II, if the historical mean quarterly demand for the item is less than one, the time between demands is assumed to be exponentially distributed with mean being one-third of the historical quarterly mean. A random number is generated from the exponential distribution whose parameter is the reciprocal of the monthly demand mean. These numbers representing inter-arrival times are sequentially added to the event list to establish the arrival time of each demand.

If the historical monthly mean is greater than or equal to one-third, then the number of demands in a month is drawn from a normal distribution with the historical mean and standard deviation. If the random number is negative, it is set equal to zero. If it is positive, the closest integer to the number is taken as the number of demands. Monthly demand quantities are determined as previously discussed. The arrival time of each demand for an item within a month is determined using a draw from a uniform distribution  $[0,1]$ . This generated value represents the arrival time (in units of a month) of a demand for an item during a month and is added to the event list.

#### 1. Assumptions

The *UICP* model utilizes many of the same assumptions as Maher (1993). The model assumptions are listed below.

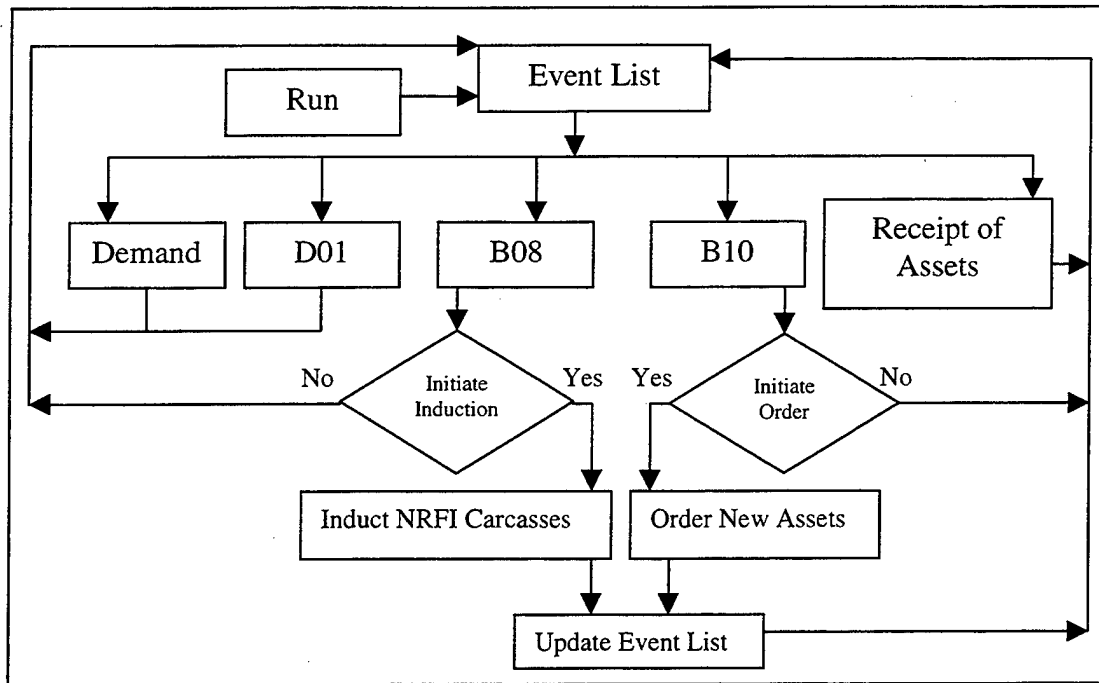
1. The numbers of demands in each month are random, with a constant mean, variance, and probability distribution, which do not change over time.
2. Every time an item fails, it creates a demand.
3. Carcass Return Rate (CRR), Repair Survival Rate (RSR), Procurement Lead Time (PCLT), and Repair Turnaround Time (RTAT) are known and constant for each National Item Identification Number (NIIN).
4. All demands have the same priority and are filled in the order of arrival time.
5. A *First Time Issue* is made immediately if on-hand inventory exists when the demand occurs. Otherwise, the demand is placed in a first-in first-out (FIFO) backorder queue.
6. All backorders have the same priority and are filled immediately when assets become available.
7. A NRFI carcass is determined to accompany a demand if the value of an independently generated random uniform between 0 and 1 is less than or equal to the CRR value.
8. If a carcass exists, a turn-in to the holding activity occurs instantaneously.
9. The Inventory Position (IP) value changes with each demand, reorder of new material, and the total number of NRFI carcasses.
10. Carcasses are inducted into the repair system in batches. The quantity inducted is multiplied by RSR to determine the number to be successfully repaired. This assumes that a percentage cannot be repaired by the repairing facility.
11. Once a batch of NRFI carcasses begins repair, the batch is returned as Ready-For-Issue (RFI) assets after a constant repair time.
12. There is no congestion at the repair facility. Repairs begin immediately once they are shipped to the repair facility.
13. Purchases are received at the supply center sequentially in the order their orders were placed.
14. Procurement of the order quantity is not constrained by budget restrictions.

15. Assets assigned to Planned Program Requirements (PPR) or War Reserves are not considered in this model when computing the on-hand inventory level, or the on-order level.
16. If a Supply Demand Review (SDR) is scheduled during a month when quarterly levels are being computed, it is scheduled after that computation.

## **B. SIMULATION STRUCTURE AND DESIGN**

All formulas within the routines used in *UICP* were derived from the concepts and ideas of Hadley and Whitin (1963) and discussed by Maher (1993). As previously discussed in Chapter II, the event list determines what event occurs and when. The "main event list" is a time sequencing of four anticipated processes. The flowchart in Figure 2 illustrates the scheduling of five main events in the simulation. Three of the five events occur at fixed times: (i) "D01", a quarterly review of levels process; (ii) "B08", a semi-monthly review to determine if repairs are required; and (iii) "B10", a monthly review to determine if the purchase of new material is required. The fourth event, "Demand", inserts the time of the random demands properly into the time sequences of the event list. The fifth event, "Receipt of Assets", includes two processes, receipt from repair and receipt from order. These are inserted at random as a result of the simulation, but are treated together as a single main event. See Figure 2.

Within each of the main events, there are numerous "sub-events" which can be randomly scheduled. The flow charts in Figures 3 through 6 illustrate the process for each of the main events depicted in Figure 2. The flowchart in Figure 7 shows the process when either items are received from the repair facility after completing repair, or an order is received from the contractor.

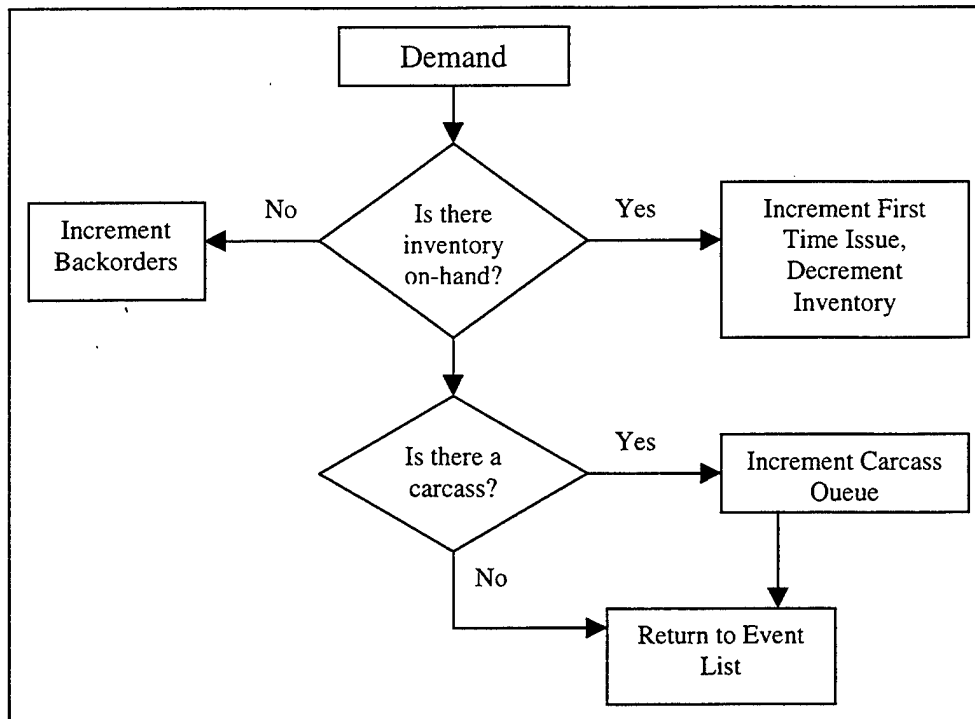


**Figure 2. Main Event List For UICP**

### 1. Demand

If the current event on the event list is a demand, it is removed from the event list and executed. The current inventory level is checked to determine if there is an asset available to fill the demand. If so, an issue is made and *First Time Issues* is incremented by one and the inventory level is decreased by one. If there are no assets available, the demand is placed in backorder and the *Total Number of Backorders* is increased by one. The time associated with the backorder is recorded so that the time in backorder status can be computed once the backorder is filled.

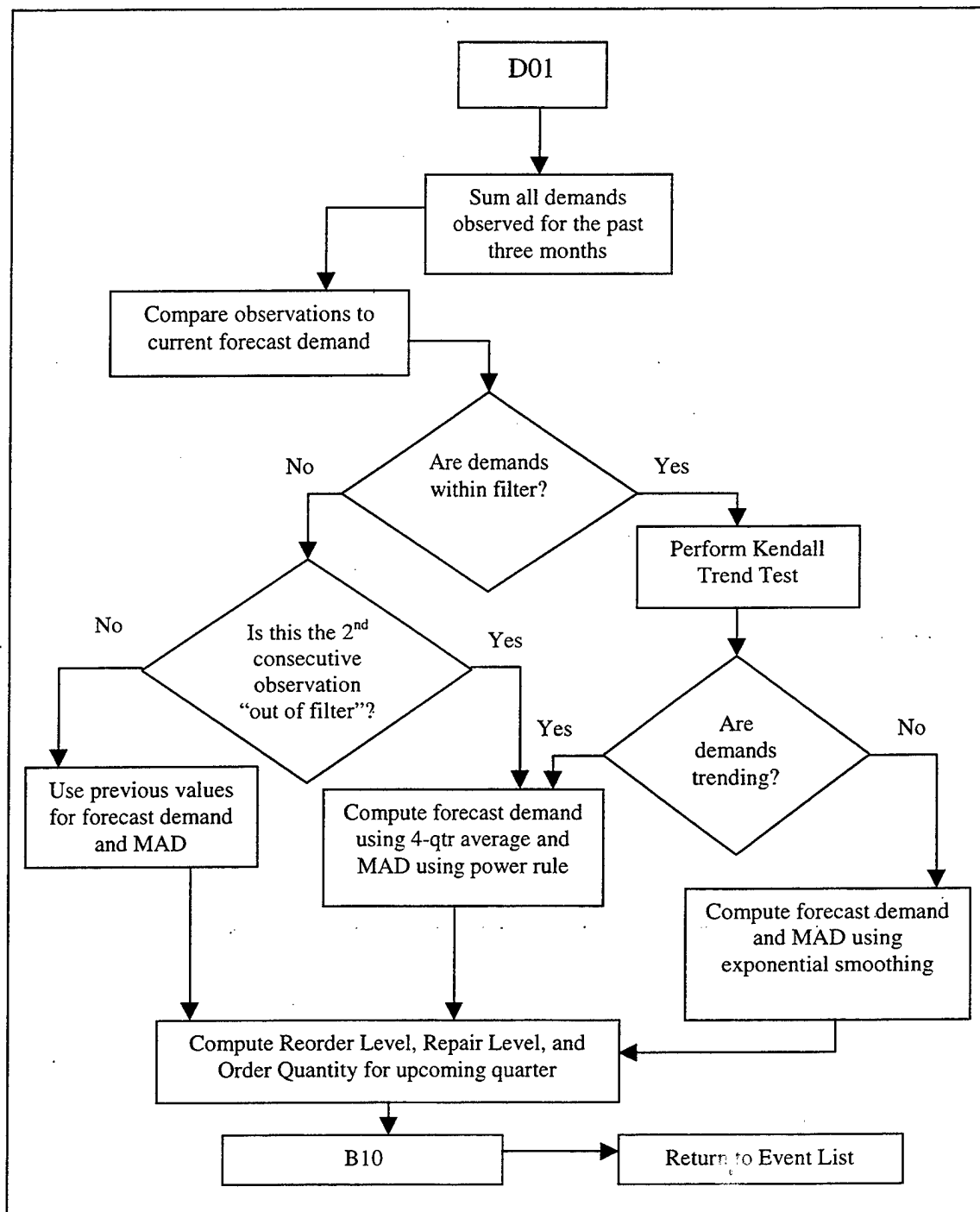
After the demand occurs, a random draw determines whether an NRFI carcass accompanies the demand. If so, the NRFI queue is increased by one to await shipment to the repair facility. If no carcass accompanies the demand, no action is taken. The model then returns to the event list.



**Figure 3. Demand Event Process**

## **2. D01 (Levels Setting Process)**

All the demands for one item occurring over the past three months are summed to compute the quarterly demand. It is compared to the forecasted demand for that same period. The forecasting process is outlined in DoN (1991) and Urban (1993). It includes a filtering process, and a trend detection technique. The process is illustrated in Figure 4.



**Figure 4. D01 (Levels Setting) Event Process**

The *UICP* model uses a single exponential smoothing (Urban 1993) technique to forecast quarterly demand and the Mean Absolute Deviation (MAD) of demand, (Urban 1993). Currently, a smoothing constant of 0.1 is used. Depending on the results of the filtering process and the Kendall test, the simulation may branch to a mathematical algorithm known as the power rule (DoN 1991). This algorithm is used in place of exponential smoothing.

The filtering process is the first step performed in the forecasting process. Prior to computing the next quarterly demand forecast, the observed demand from the most recent quarter is analyzed to determine if it falls within certain limits. As Robillard (1994) discusses, this process is referred to as “step” filtering and determines if there has been a significant change in the mean. A significant change in the mean is defined to be two consecutive demand observations either exceeding an upper control limit or failing to meet a lower control limit. If either case occurs, the forecast is computed as the average of the four most recent observations; the power rule algorithm is used to compute the forecasted MAD. If only the most recent observation is out of the control limit, the demand and MAD forecasts are not updated. If the most recent observation is within the control limits, then a trend detection test developed by Boyarski and Bissinger (1990) is performed.

The trend test algorithm consists of a statistical test using a “window” to determine if the demand is trending (Robillard 1994). The size of the “window” is a function of the mean and variance of the demand. In turn, the statistical test depends upon the window size and variability for the demand. If a trend is detected, the next quarter’s demand forecast is computed using a four-quarter average, and the MAD is

computed using the power rule algorithm. The exponential smoothing technique is used for the follow-on quarters provided the filter and trend tests are passed, as discussed.

Once the quarterly demand and MAD forecasts have been computed for the upcoming quarter, levels must be reset. This requires the computation of the constrained Order Quantity ( $\hat{Q}$ ), constrained Reorder Level ( $\hat{R}$ ), and constrained Repair Level ( $\hat{R}_2$ ) for each quarter. At the NAVICP, the levels setting program PD-82 (McNertney and Reynolds, 1993) is used to determine these levels.

There is a two-step process involved with calculating these values. First, a value is computed using formulas derived in Maher (1993). These values are then compared with a series of limitations and then adjusted, resulting in a “constrained” value. These constraints apply a minimum and maximum value to the associated levels.

Prior to computing  $\hat{Q}$ ,  $\hat{R}$ , and  $\hat{R}_2$ , the probability of a stockout (referred to as RISK) and the number of demands that occur during a NAVICP defined “average acquisition” time (referred to as Procurement Problem Variable or Z) is computed (DoN, 1991).

#### **a. RISK**

The original *RISK* equation was developed from the Total Variable Cost (TVC) equation as shown by Maher (1993). NAVICP assumes lead time demand is large enough to use the Normal distribution for approximating the Poisson distribution. To ensure the calculated procurement level provides sufficient carcasses to meet the requirement set by the repair level, NAVSUP developed an integrated *RISK* formula to compute the safety level used in the computation of  $\hat{R}$  and  $\hat{R}_2$ . The formula is,

$$RISK = \frac{DIC_3}{DIC_3 + \lambda FE} \quad (12)$$

where

$$C_3 = \left(\frac{G}{D}\right)(C_2) + \left(1 - \frac{G}{D}\right)(C)$$

$D$  = forecast of quarterly demand  
 $I$  = holding rate (capital + obsolescence + storage costs).  
 $G$  = quarterly regeneration forecast of ready for issue items from the repair facility.  
 $C_2$  = cost to repair one unit  
 $C$  = unit price of the item  
 $E$  = mission essentiality code (usually one)  
 $F$  = average number of items in a request from the fleet.  
 $\lambda$  = shortage cost per request (constant value for each item).

#### b. Procurement Problem Variable (Z)

In a model that incorporates a repair process, a percentage of those demands during a procurement lead time will have a number of associated NRFI carcasses that can be fully repaired or regenerated (G) within that same lead time. The NAVICP has defined this concept as the demand during an "average acquisition" time and called it the Procurement Problem Variable. Its formula is,

$$Z = DL - GL + GT, \quad (13)$$

where

$G$  = quarterly regeneration of ready for issue items from the repair facility.  
 $L$  = procurement lead time in quarters  
 $T$  = Repair Cycle Time  
 Repair Cycle Time = RTAT + Time between repair cycles  
 Time between repair cycles = 0.19 quarters

### c. Constrained Order Quantity ( $\hat{Q}$ )

The Economic Order Quantity (EOQ) is obtained from minimizing the total variable cost (TVC) equation with respect to  $Q$  (Maher 1993). The result is an initial order quantity,  $Q^*$ ,

$$Q^* = \sqrt{\frac{8(D-G)A}{IC}} \quad (14)$$

where

- $A$  = administrative costs associated with an order
- $D$  = forecast demand for quarter
- $G$  = quarterly regeneration of ready for issue items from the repair facility.
- $C$  = unit price of the item
- $I$  = holding rate (capital + obsolescence + storage costs).

Equation (14) can result in an extremely high or low value. To protect against this, NAVICP constrains  $Q^*$ . The first set of constraints applied to  $Q^*$  ensures that the order quantity does not exceed one and a half years of attrition demand and is not less than 6 months worth of attrition demand. (Attrition demand is the difference between total demands and the number of those demands that could be regenerated). It also ensures that at least one asset is ordered. Its application is,

$$\tilde{Q} = \min \left\{ \begin{array}{l} 6(D-G) \\ \max \left\{ \begin{array}{l} Q^* \\ K_0(D-G) \end{array} \right\} \\ 2(D-G) \end{array} \right\} + 0.5 \quad (15)$$

where

- $(D-G)$  = attrition demand.  
those demands that had no accompanying carcass  
or that could not be repaired by the repair facility.
- $K_0$  = NAVICP-set value to ensure the minimum order  
quantity is at least one.

$\tilde{Q}$  is then constrained to ensure that on-hand RFI assets do not deteriorate due to shelf life. Its application is,

$$\hat{Q} = \min \left\{ \tilde{Q}, 4(D - G)H - \max \left\{ 0, \hat{R} - Z \right\} \right\} + 0.5 \quad (16)$$

where

$$\begin{aligned} \hat{R} &= \text{constrained reorder level} \\ Z &= \text{net demand during lead time} \\ H &= \text{shelf life} \end{aligned}$$

#### d. Constrained Reorder Level ( $\hat{R}$ )

As discussed in Chapter II, the unconstrained reorder level,  $R$ , is the net demand during an "average acquisition" time plus a safety level:

$$R = Z + t\sigma_{DLR}, \quad (17)$$

where  $Z$  is the Procurement Problem Variable (equation 13),  $\sigma_{DLR}$  is the standard deviation of the Procurement Problem Variable Variance (PPVV) discussed below (equation 20), and  $t$  is the standard normal deviate associated with the computed *RISK*, (equation 12). The value  $t$  is computed using the approximation formula found in McNertney and Reynolds (1993) and provided as equation 19.

$$\sigma_{DLR} = \sqrt{PPVV} \quad (18)$$

$$t = n - \left\{ \frac{A_0 + A_1n + A_2n^2}{1 + B_1n + B_2n^2 + B_3n^3} \right\} \quad (19)$$

where

$$\begin{aligned} n &= \sqrt{-2\ln(RISK)} \\ A_0 &= 2.515517 \\ A_1 &= 0.802853 \\ A_2 &= 0.010328 \\ B_1 &= 1.432788 \end{aligned}$$

$$B_2 = 0.189269$$

$$B_3 = 0.001308$$

The Procurement Problem Variable Variance ( $\sigma^2_{DLR}$ ) is computed using the formula developed by Bissinger (1995).

$$PPVV = \left\{ (1 - R_I R_2)^2 \left[ L \sigma_D^2 + D^2 \sigma_L^2 \right] \right\} + \left\{ \left( R_I^2 R_2^2 \right) \left[ T \sigma_D^2 + D^2 \sigma_T^2 \right] \right\} + \left\{ (2 R_I R_2) (1 - R_I R_2) \left[ L T \sigma_D^2 \right] \right\} \quad (20)$$

where

- $R_I$  = probability that the failed item (carcass) will accompany a demand. Referred to as Carcass Return Rate (CRR).
- $R_2$  = probability that a NRFI carcass can be repaired by the repair facility. Referred to as Repair Survival Rate (RSR).
- $L$  = Procurement Lead Time (PCLT)
- $T$  = Repair Cycle Time (RCT)
- $\sigma_D^2$  = Forecasted Demand Variance ( $1.57 * MAD^2$ )
- $\sigma_L^2$  = PCLT Variance (constant value)
- $\sigma_T^2$  = RCT Variance (constant value)

The first step for constraining the reorder and associated safety level is to constrain the *RISK* factor, equation (12). The constrained *RISK* equation is written:

$$RISK = \min\{maxallowableRISK, [max(RISK, minallowableRISK)]\}. \quad (21)$$

The maximum allowable *RISK* factor is used to ensure a low probability of stock-out on high-demand items. A value of 0.35 is used when the average requisition frequency for the item is greater than or equal to one per quarter. Otherwise, a value of 0.5 is used. Conversely, the minimum allowable *RISK* factor ensures there is not an extremely large safety level, particularly on low cost items. This value is always 0.05.

The second step in computing the reorder level is to ensure that the constrained reorder point is at least one by implementing a NAVICP-set Numeric Stockage Objective (NSO), and no less than a NAVICP-set percentage of the Procurement Problem Variable. Additionally, the safety level is constrained to a level where it does not exceed the amount that will be used during the shelf life (H) of the item. The constrained reorder level  $\hat{R}$  is calculated as follows:

$$\hat{R} = \max \left\{ \begin{array}{l} NSO \\ K_1 Z \\ \min \left\{ \begin{array}{l} Z + t\sigma_{DLR} \\ Z + (D - G)(4H - K_0) \end{array} \right\} \end{array} \right\} \quad (22)$$

where

$NSO =$  NAVICP-set value for low demand items to ensure a minimum stockage level (usually one)  
 $K_1 =$  NAVICP-set value to ensure the safety level and reorder level do not fall below a  $(1-K_1)$  percentage of the Procurement Problem Variable (equation 13).

**e. Constrained Repair Level ( $\hat{R}_2$ )**

The final level computed is the repair level, which is the expected number of demands during a repair cycle. It is used to determine if carcasses in the holding area need to be shipped to the repair facility. The unconstrained repair level is computed as the net demand during RTAT ( $Z_2$ ), plus the safety level. NAVICP computes the safety level as the difference between  $\hat{R}$  (equation 22) and  $Z$  (equation 13). This is equivalent to the safety level calculated using equation (17).

$$\hat{R}_2 = Z_2 + (\hat{R} - Z) \quad (23)$$

The constrained repair level ( $\hat{R}_2$ ), is computed using the following equation:

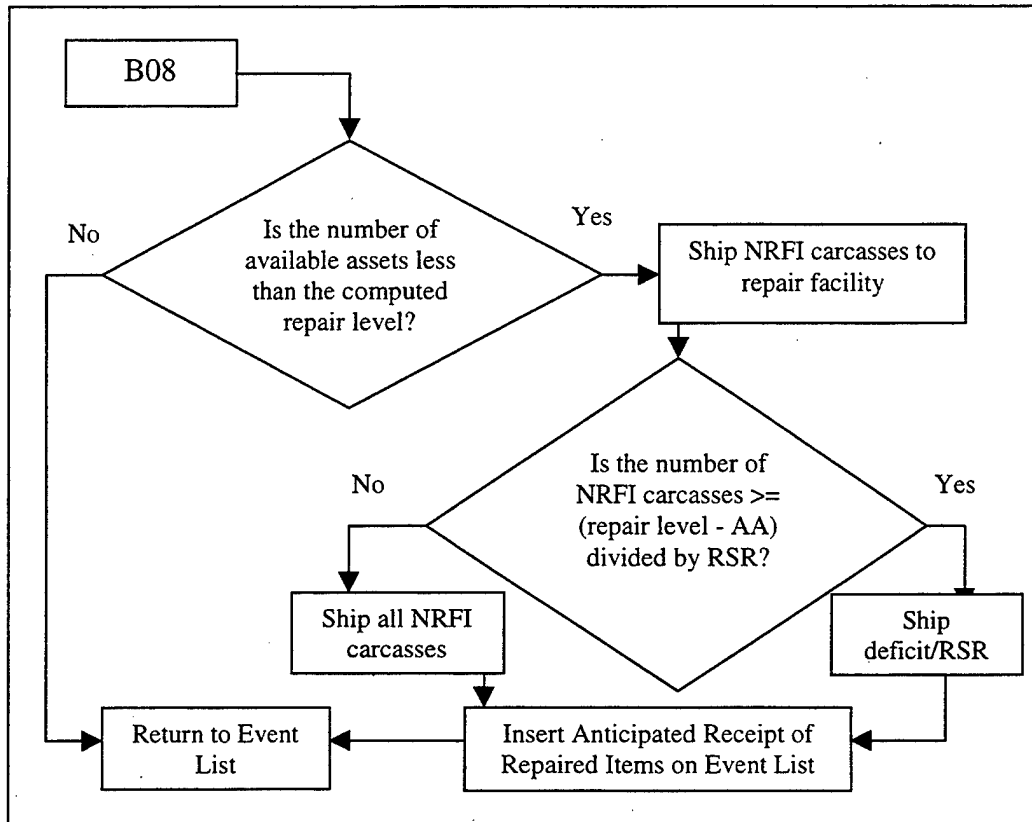
$$\hat{R}_2 = \max \left\{ \begin{array}{l} NSO \\ K_1 Z_2 \\ \min \left\{ \begin{array}{l} R_2 \\ 4DH + Z_2 - 1 \end{array} \right\} \end{array} \right\} + 0.5 \quad (24)$$

where

$K_1 Z_2$  = NAVICP-set constraint to ensure the safety level is constrained to a percentage of the forecasted demand and on-hand assets.

### 3. B08 (Review Repair)

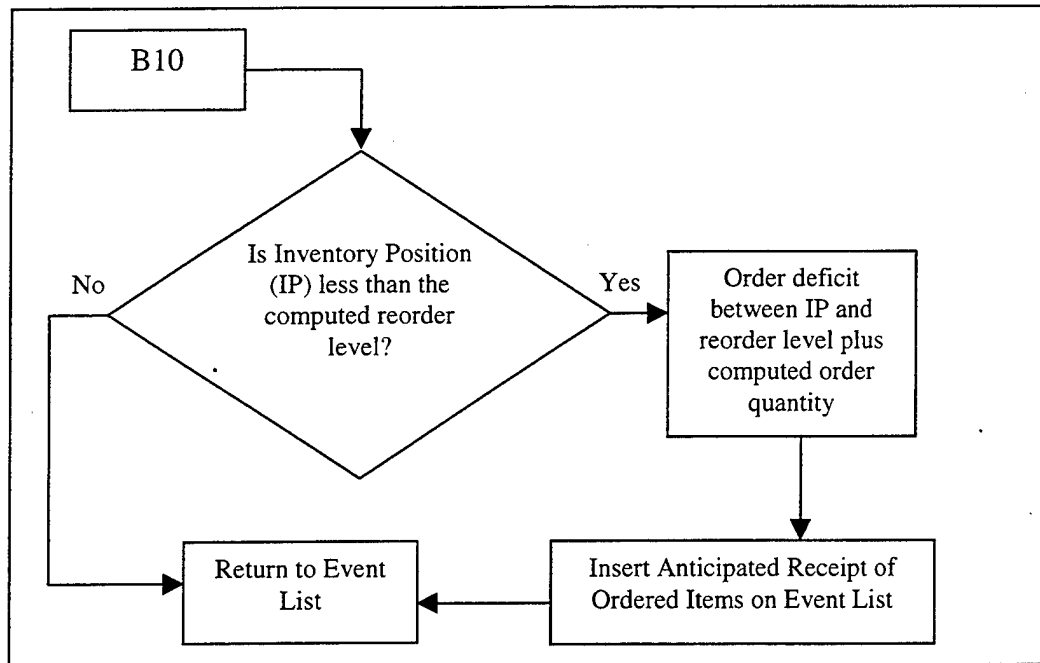
The B08 routine is scheduled semi-monthly. If AA (equation 8) is less than  $\hat{R}_2$  (equation 24), then NRFI carcasses must be shipped to the repairing facility for repair. The actual quantity shipped to the repair facility is the deficit between AA and  $\hat{R}_2$ , divided by the repair survival rate (RSR). As discussed in the assumptions, if there are insufficient NRFI carcasses available, then all on-hand NRFI carcasses are shipped. The quantity in the carcass queue is updated by subtracting the quantity shipped from the total number of carcasses in the queue. The sum of an RTAT and the current simulation time represents the arrival time of the repaired assets from the repair facility. The event list is updated with the anticipated arrival of assets at the computed time. See Figure 5.



**Figure 5. B08 (Review Repair) Event Process**

#### **4. B10 (Supply Demand Review)**

The B10 or Supply Demand Review (SDR) routine is scheduled monthly. As discussed in the assumptions, if it is scheduled during a month when the decision variables (levels) are reset, then this routine is run immediately after this action and not before. The purpose of this routine is to determine if adequate assets are available throughout the repair pipeline to support forecasted demand. If  $IP$  (equation 6) is less than  $\hat{R}$  (equation 22), then a procurement action is initiated. The quantity ordered is  $\hat{Q}$  (equation 16), plus the difference between  $IP$  and  $\hat{R}$ . The SDR process is illustrated in Figure 6.

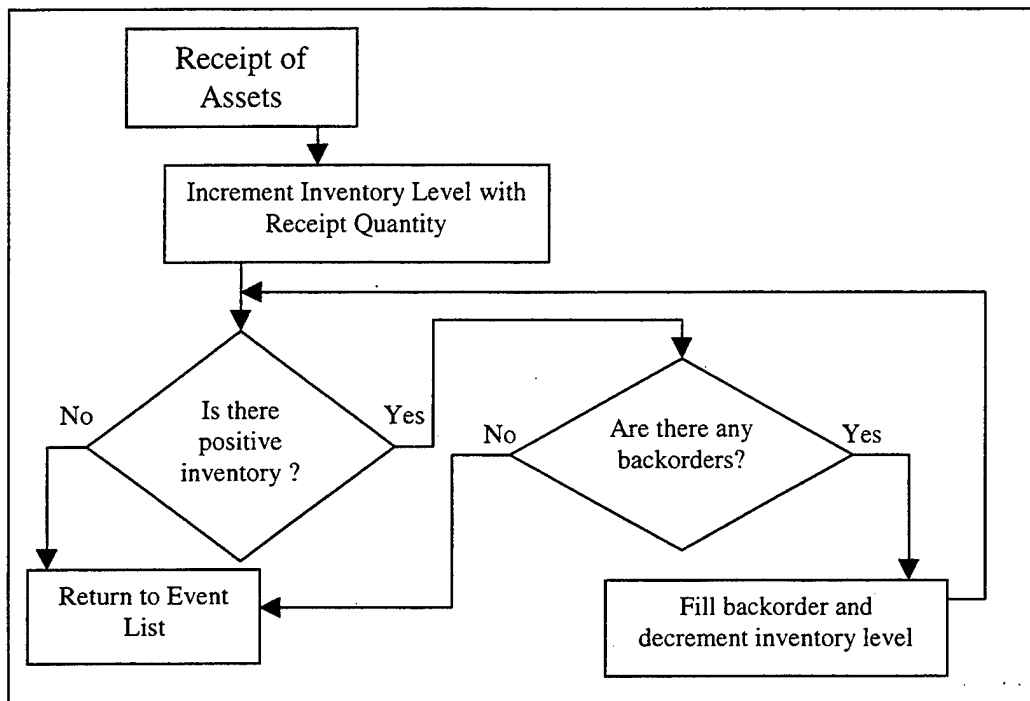


**Figure 6. B10 (Supply Demand Review) Event Process**

### **5. Receipt of Assets**

When a repair or order is made, the time of receipt of the repaired or ordered item is anticipated and inserted into the event list. The processing of the receipt begins with the updating of the inventory level account. When assets are received, the inventory level is incremented by the quantity received. The model then determines if there are any backorders in the system. If so, the oldest backorder (first in the queue) is removed and filled. At the same time, the inventory level is decreased by one. The simulation time is recorded and the difference is calculated between that time and the time the demand entered backorder. This difference represents the time that demand remained in backorder status. The model then determines if a positive inventory level still exists and if there are more demands in backorder. If so, the process repeats. This process

continues until either there is no longer a positive inventory level, or there are no more demands in backorder. See Figure 7.



**Figure 7. Receipt of Assets Process**



#### IV. BAND SIMULATION

The beginning of this chapter discusses the background associated with the *BAND* simulation. The remainder of the chapter is similar to the structure in Chapter III. It discusses the *BAND* simulation and assumptions, followed by the structure and design of the simulation.

##### A. BACKGROUND

Recall this concept calls for the determination of a monthly procurement quantity based on historical demand and establishing a long-term contract with the company to have that quantity delivered every month. The simulation developed for this thesis includes the modeling of the items which can be repaired, unlike the process described in Stewart and Frazier, 1996.

##### B. DISCUSSION

Input parameters provided by the user to *BAND* are contained in Appendix C, along with their associated definitions.

As with *UICP*, demands are generated based on the mean and standard deviation of the historical demand data. The demand generating process is the same as discussed for *UICP*.

##### 1. Assumptions

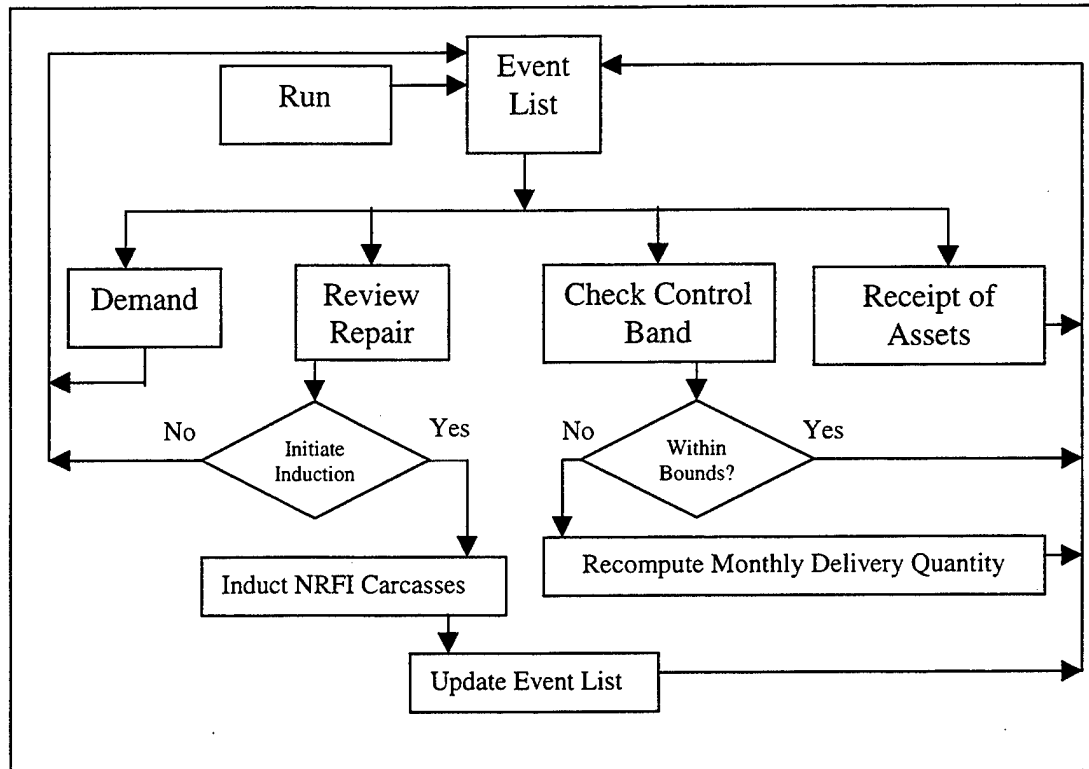
The same assumptions discussed in Chapter III apply to this model. Additionally, the following assumptions are specific to *BAND*, as a result of incorporating the repair process:

1. The confidence interval (CI) for the control band is plus and minus two standard deviations of the mean demand. It is the same CI used by the filter process in *UICP*.

2. Forecasted demand, repair level, and delivery quantity are computed monthly (instead of quarterly).
3. A procurement cycle is one month long since deliveries are made on a monthly schedule.
4. Net demand during lead time refers to the expected number of demands during the upcoming month that cannot be filled with repaired assets.
5. The initial inventory level is the expected demand over half a month plus a fixed time to repair and return the item (RTAT). This ensures there are sufficient assets on hand to cover any demands prior to the first induction of failed items from the holding facility and the time required to repair those NRFI carcasses shipped from the holding facility.
6. The DELQTY is computed at the beginning of each month. If the quantity changes, the new quantity is delivered the following month.
7. Cost is not a factor in determining the repair level; only the expected number of repaired items during the next cycle is needed.

### C. SIMULATION STRUCTURE AND DESIGN

The flow chart in Figure 8 illustrates the process for the four main simulation events that will occur in the **BAND** model. Two of the four main events occur at fixed times: (i) semi-monthly "Review Repair", which implements the repair policy; and (ii) a monthly "Check Control Band", which determines the monthly delivery quantity policy. The third simulation event, "Demand", inserts randomly generated demands into the time sequencing of the event list in the same manner as the **UICP** model. The sub-events, receipt from repair and the monthly delivery from the contractor, are combined into the fourth event, "Receipt of Assets". These sub-events are scheduled into the event list randomly as a result of the simulation. See Figure 8.

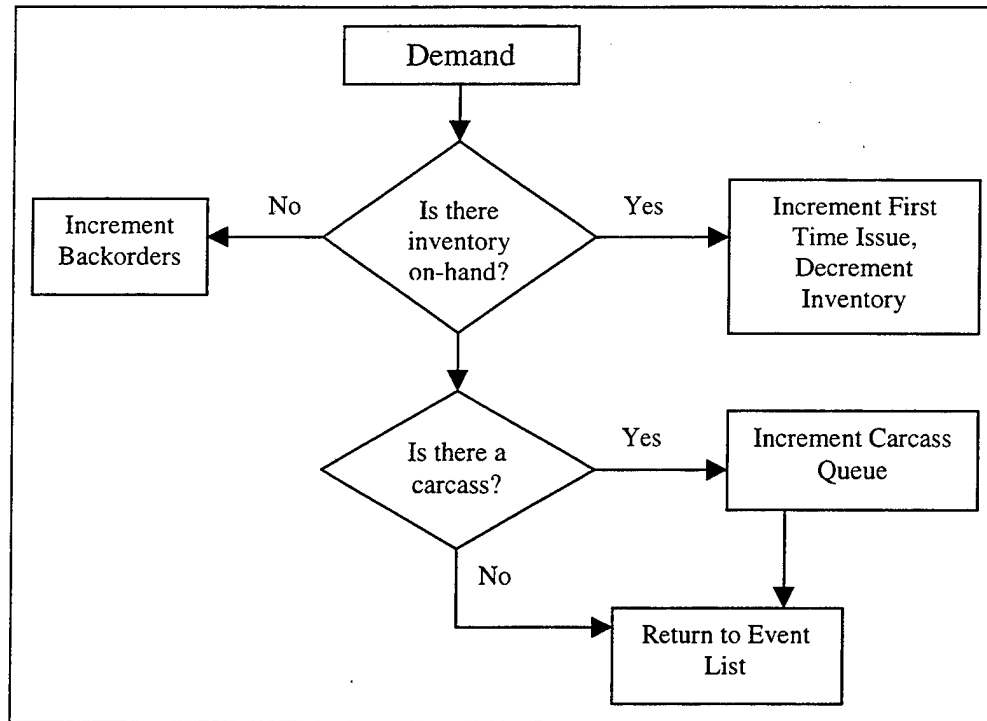


**Figure 8. Main Event List for *BAND***

As with the *UICP* model, there are numerous “sub-events” which can be randomly scheduled. The flow charts in Figures 9-11 illustrate the process for each of the main events depicted in Figure 8. The flowchart in Figure 12 shows the process when a receipt is received from the repair facility or from the contractor.

### 1. Demand

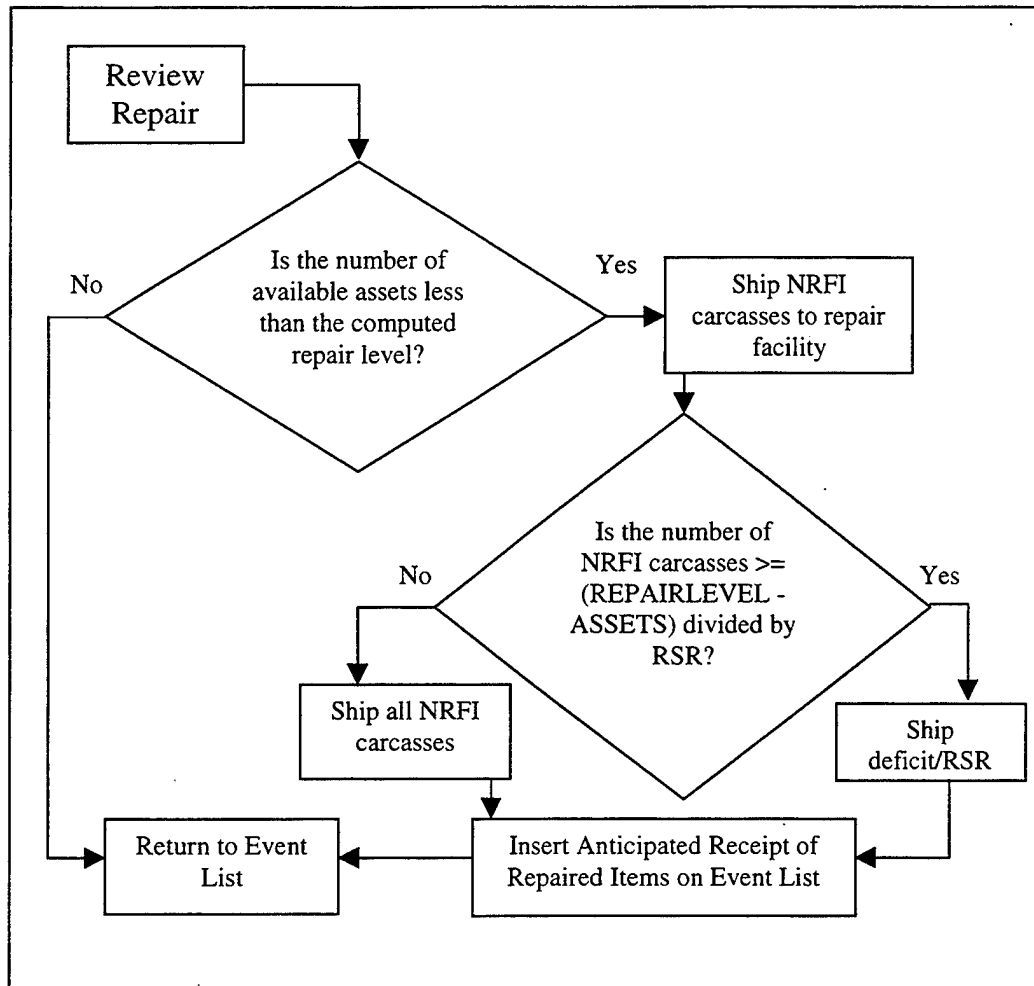
This process (see Figure 9) is implemented as in the *UICP* simulation. Each demand is either filled if a positive inventory exists, or it is placed in backorder; accounts are updated.



**Figure 9. Demand Event Process**

## 2. Review Repair

The implementation of this event is similar to that in the *UICP* simulation. The only difference is the method used to calculate the repair level. The Review Repair routine is scheduled twice a month. If *ASSETS* (equation 11) is less than *REPAIRLEVEL* (equation 10), the model determines that *NRFI* carcasses must be shipped to the repair facility for repair. The quantity shipped is the difference between *ASSETS* and *REPAIRLEVEL* divided by the survival rate (*RSR*). As discussed in the assumptions in Chapter III, if there are insufficient *NRFI* carcasses on-hand to meet the required induction quantity, then all on-hand carcasses are shipped. As in the *UICP* model, the quantity in the carcass queue is updated to reflect the carcasses shipped to the repair facility. The Review Repair process is illustrated in Figure 10.



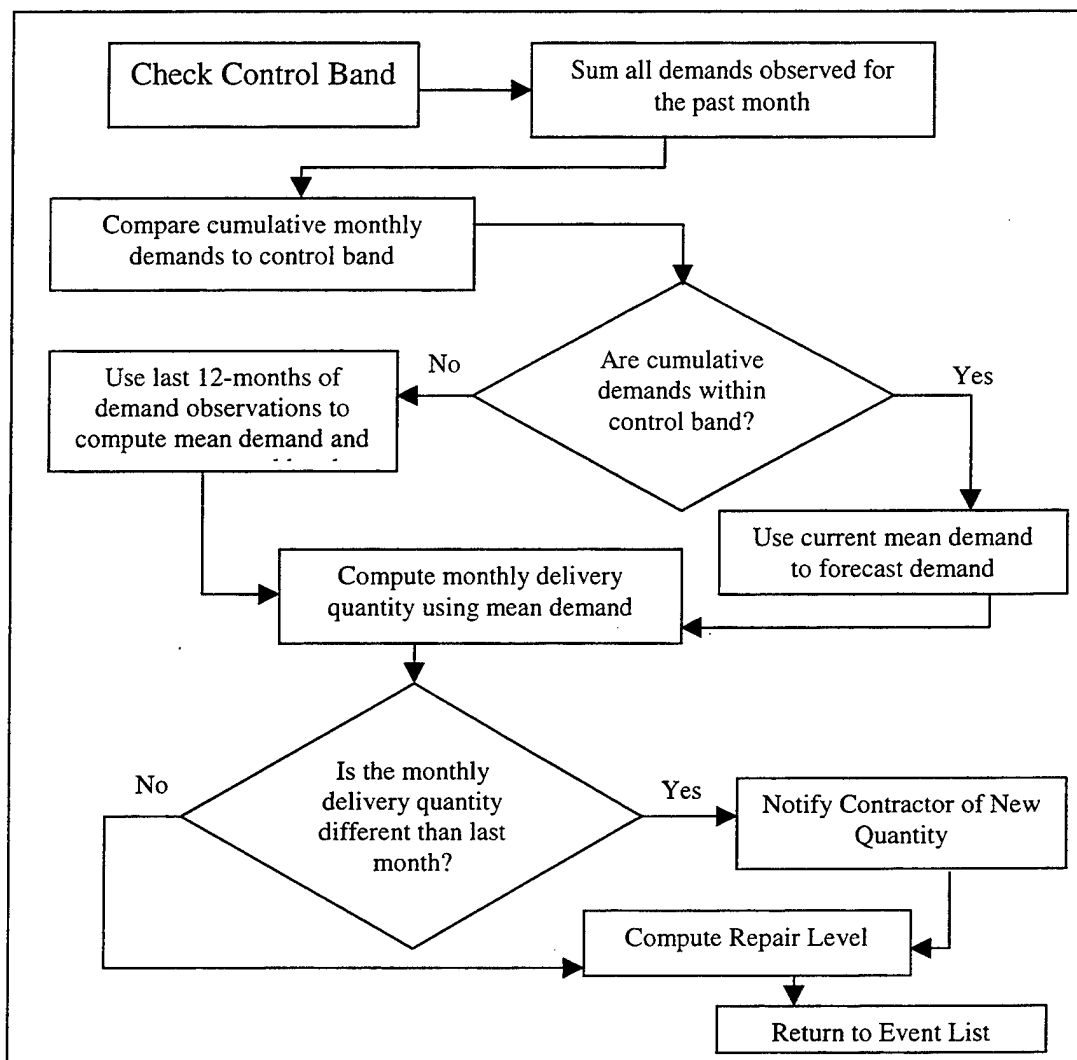
**Figure 10. Review Repair Process**

### 3. Check Control Band

This event determines if the observed monthly demand falls within the computed control band, that is, the cumulative mean number of demands plus or minus two standard deviations. Each month, the total number of demands from the most recent month are collected into a monthly bucket and used to forecast the size of the demand for the upcoming month. The current monthly demand observations are added to the cumulative observed number of demands. This value is compared to the cumulative forecasted demand. If the actual cumulative demand falls outside the control band, then the new average number of demands and associated standard deviation are computed

using the last 12-months of actual demand. Otherwise, the mean and standard deviation remain the same as the previous month.

After a new mean and standard deviation are determined, the new demand forecast for the upcoming month is computed. This forecast is used to compute control limits, REPAIRLEVEL and DELQTY. If the value of DELQTY changed from the previous month, the contractor is notified of the new quantity and is required to deliver the new quantity the following month. See Figure 11.



**Figure 11. Check Control Band Process**

#### 4. Receipt of Assets

Assets are received from the repair facility in the same manner as the *UICP* simulation. Assets are received from the contractor as negotiated in the initial contract. The quantity represents the expected assets lost to attrition during the previous month. The inventory level is incremented by the quantity received by either the repair facility or the contractor. If any backorders exist in the system, the oldest backorder (first in the queue) is removed and filled. At the same time, the inventory level is decreased by one. The simulation time is recorded and the difference is calculated between that time and the time the demand entered backorder. This difference represents the time that demand remained in backorder status. As with the *UICP* model, this process continues until there are no longer any assets available in inventory, or there are no more demands in backorder. See Figure 12.

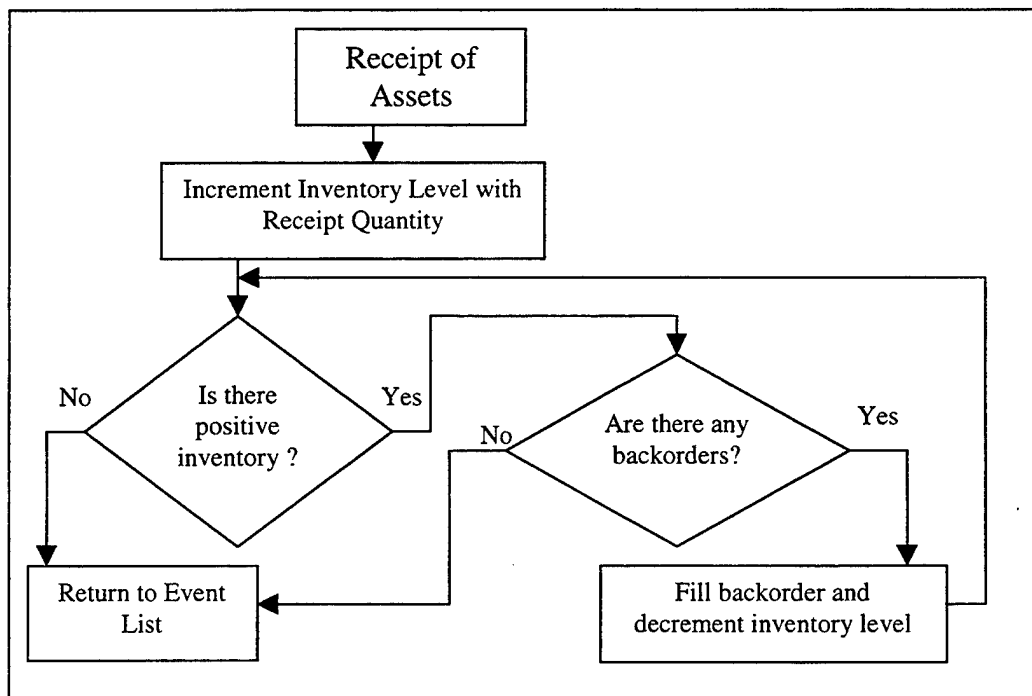


Figure 12. Receipt of Assets Process



## V. ANALYSIS

### A. OVERVIEW

Simulation is a unique type of experiment because there is more control over inputs or factors than can usually be achieved in a physical experiment with a system (Robillard 1994). Factor selection becomes even more critical in research such as this since it is directed toward the comparative performance of two systems.

For this research, the following factors are kept constant in both simulations: Carcass Return Rate (CRR), Repair Survival Rate (RSR), and Repair Turnaround Time (RTAT). The historical values are found in Appendix F. The random number sequence is the same for both the *UICP* demand and the *BAND* demand, enabling the monthly demand stream to be exactly the same. Comparison of system performance is based on three formal measures of performance (MOE) discussed earlier: Supply Material Availability (SMA), Average Delay for Delayed Requisitions (ADDR), and Average Monthly Investment Level (AMIL).

### B. INITIAL SIMULATION RESULTS

The simulation is required to run for 60 months in order for the inventory system to achieve steady-state operation. Initially, the system is empty, and demands are generated to establish assets in the repair and procurement pipeline. After 60 months, summary statistics are collected from the simulation run for an additional 600 months. The first comparison examines the performance of *UICP* and *BAND*. Each simulation replication consists of a total of 240 separate trials, one for each item. The data needed to compute the MOE statistics are recorded for each item. After one replication is completed, the data for each MOE are summed over all 240 items and the MOE statistics are computed. The value for each performance measure is then recorded. This process is

repeated for thirty replications. Equations 25-27 illustrate the formulas used to compute the performance measures for each replication. The results from one replication of each system by individual identification number are found in Appendices G and H.

$$SMA = \frac{\sum_{n=1}^{240} FirstTimeIssues_n}{\sum_{n=1}^{240} Demands_n} \quad (25)$$

$$ADDR = \frac{\sum_{n=1}^{240} TotalTimeofAllBackorders_n}{\sum_{n=1}^{240} TotalNumberOfBackorders_n} \quad (26)$$

$$AMIL = \sum_{n=1}^{240} AvgMonthlyInventoryLevel_n * I * UnitPrice_n \quad (27)$$

where

$n$	=	the item being analyzed
$FirstTimeIssues_n$	=	number of immediate satisfactions of demand requests for item $n$ .
$Demands_n$	=	total number of demands for item $n$ .
$TotalTimeofAllBackorders_n$	=	cumulative sum of waiting time in backorder for each demand of item $n$ placed in backorder status.
$TotalNumberOfBackorders_n$	=	total number of demands of item $n$ placed in backorder.
$AvgMonthlyInventoryLevel_n$	=	average quantity per month of item $n$ in stock available to satisfy a demand.
$I$	=	variable holding rate.
$UnitPrice_n$	=	unit price associated with item $n$ .

The MOE values for each replication of **BAND** are subtracted from the associated MOE values of **UICP**. The mean of these differences is computed to determine a point estimate. A 95% confidence interval for the point estimation is also calculated. The

point estimate and associated confidence interval for each performance measure are presented in Table 5.1.

Since a high SMA indicates better performance, the positive difference indicates *UICP* performs better for that MOE. Conversely, lower values for ADDR and AMIL are better, so the negative difference indicates the *UICP* system performs better. The columns of Table 5.1 correspond to the measures of effectiveness identified in Section A of both Chapters III and IV. The first row corresponds to the point estimate, the second row indicates the confidence interval associated with the differences of the two systems, and the last row indicates which model is preferred based on performance values for each particular measure.

The results clearly indicate that *UICP* performs better than *BAND*.

**Table 5.1 Comparison of *UICP* and *BAND* Using all 240 NIINs.**

MOE	SMA	ADDR	AMIL (\$K)
<b>Point Estimate</b>	0.218	-19.4534	-82.15
<b>CI of Differences (95% CI)</b>	0.138- 0.298	-12.07- -26.83	-52.16- -112.13
<b>Preferred Model</b>	UICP	UICP	UICP

### C. SENSITIVITY ANALYSIS ON *BAND*

After comparing the overall results for the 240 items, additional analysis is performed based on an item's replacement cost. The items are partitioned into five categories which are defined by disjoint cost intervals. Table 5.2 shows the results after running ten replications for each system. The first column in the table lists the cost interval and the corresponding number of items in each interval. The remaining three columns list the three measures of effectiveness.

Although **BAND** maintains lower inventory cost for items with replacement costs less than \$2500, the SMA and ADDR are still relatively inferior when compared with **UICP**.

**Table 5.2 Comparison of *UICP* and *BAND* Based Upon the Cost to Replace the Item.**

Cost Interval(\$): # of items	SMA	ADDR	AMIL (\$K)
<b>0-700 : 46</b>			
Point Estimate	0.277	-16.17	1.037
CI of Differences (95 %)	0.095-0.459	-4.82- -27.53	0.316- 1.76
Preferred System	UICP	UICP	BAND
<b>701-1400 : 51</b>			
Point Estimate	0.139	-29.89	2.724
CI of Differences (95 %)	0.048-0.23	-10.26- -49.52	0.931- 4.52
Preferred System	UICP	UICP	BAND
<b>1401-2500 : 50</b>			
Point Estimate	0.254	-30.19	3.766
CI of Differences (95 %)	0.088-0.420	-10.43- -49.95	1.288-6.243
Preferred System	UICP	UICP	BAND
<b>2501-5500 : 45</b>			
Point Estimate	0.134	-20.27	-47.215
CI of Differences (95 %)	0.045-0.223	-7.00- -33.53	-16.357- -78.072
Preferred System	UICP	UICP	UICP
<b>5501-73,000 : 48</b>			
Point Estimate	0.121	-13.628	-39.591
CI of Differences (95 %)	0.039-0.202	-4.570- -22.686	-13.597- -65.585
Preferred System	UICP	UICP	UICP

#### **D. MODIFICATION OF *BAND***

A variation of the **BAND** system, called **THIRD**, is considered, which incorporates an immediate buy concept. This concept prevents the inventory system from sustaining a large number of backorders for extended periods of time during periods of high demand. It requires that the system determine whether there are sufficient RFI and NRFI assets in the pipeline to fill existing backorders within a one-month period.

The immediate buy procedure is employed whenever the cumulative observed demand exceeds the upper control limit. The procedure compares the number of existing backorders to the total number of available assets in the supply system. The number of available assets is computed by summing the on-hand assets, assets scheduled to complete repair within an RTAT, carcasses at the holding facility awaiting shipment to the repair facility, and the monthly delivery quantity. Equation (28) refers.

$$AVAILASSETS = O/H + RFI\ DUE\ IN + (NRFI\ on-hand * RSR) + DELQTY \quad (28)$$

where

<i>O/H</i>	=	<i>current number of RFI items in inventory</i>
<i>RFI Due In</i>	=	<i>number of NRFI carcasses currently being repaired by the repair facility due to be available within an RTAT.</i>
<i>NRFI on-hand</i>	=	<i>total number of Not Ready for Issue (NRFI) that are at the holding facility waiting to be shipped to the repair facility</i>
<i>RSR</i>	=	<i>probability that a NRFI carcass can be repaired by the repair facility. Referred to as Repair Survival Rate.</i>
<i>DELQTY</i>	=	<i>monthly delivery quantity</i>

Figure 11 can be modified to reflect this policy change. If the number of backorders exceeds AVAILASSETS, the contractor is notified that a number of additional assets are required. The contractor will deliver the additional number within two months. This quantity is a "one-time buy" and is exclusive of the regularly scheduled monthly delivery. The quantity is equal to the difference between the number of backorders and AVAILASSETS. The process illustrated in Figure 12 applies once these assets are delivered.

Thirty replications of the simulation are generated for this system in the same manner as the *BAND* system. The results from one replication by individual

identification number are presented in Appendix I. Using the same methodology as before, the *THIRD* and *UICP* are compared after each replication. The mean of the differences for each performance measure is computed to determine the point estimate for that particular measure, and the SE of the mean is computed to determine a 95 percent CI. Table 5.3 presents the global comparison of the results between *THIRD* and *UICP*. As with the analysis for *BAND*, a positive difference for SMA indicates that the *UICP* system performed better than the *THIRD* system. This also applies to a negative difference value for ADDR and AMIL. If the mean difference is negative, then the *UICP* system performed better when compared to the *THIRD* system.

**Table 5.3 Comparison of *UICP* and *THIRD* for all 240 NIINs.**

MOE	SMA	ADDR	AMIL (\$K)
Point Estimate	0.0330	-17.3398	-164.39
CI of Differences (95% CI)	0.020- 0.046	-10.73- -23.95	-104.52- -224.27
Preferred Model	UICP	UICP	UICP

Although this procedure performed better than *BAND* in all three measures of performance, it did not perform better than the *UICP* system.

#### **E. SENSITIVITY ANALYSIS ON *THIRD***

The same strategy used in Section C is used with *THIRD*. Ten replications are run for each of the five cost categories. The results are illustrated in Figure 5.4.

**Table 5.4 Comparison of *UICP* and *THIRD* Based Upon the Cost to Replace the Item.**

Cost Interval(\$) : # of items	SMA	ADDR	AMIL (\$K)
<b>0-700 : 46</b>			
Point Estimate	0.041	-13.36	-5.061
CI of Differences (95 %)	0.013-0.069	-4.60- -22.13	-1.748- -8.373
Preferred System	UICP	UICP	UICP
<b>701-1400 : 51</b>			
Point Estimate	-0.035	-18.57	-10.367
CI of Differences (95 %)	-0.003- -0.067	-6.27- -30.88	-3.660- -17.615
Preferred System	THIRD	UICP	UICP
<b>1401-2500 : 50</b>			
Point Estimate	0.073	-24.04	-11.255
CI of Differences (95 %)	0.024-0.121	-8.23- -39.85	-3.766- -18.744
Preferred System	UICP	UICP	UICP
<b>2501-5500 : 45</b>			
Point Estimate	0.048	-18.78	-63.787
CI of Differences (95 %)	0.014-0.081	-6.48- -31.09	-22.104- -105.470
Preferred System	UICP	UICP	UICP
<b>5501-73,000 : 48</b>			
Point Estimate	0.052	-14.19	-71.748
CI of Differences (95 %)	0.014-0.091	-4.90- -23.48	-24.728- -118.767
Preferred System	UICP	UICP	UICP



## VI. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### A. SUMMARY

The Naval Inventory Control Point (NAVICP) is responsible for the procurement, repair, and management of over 375,000 spare parts. These include parts for ships, submarines, Naval aircraft, and all associated weapon systems and related test equipment.

NAVICP uses the Uniform Inventory Control Program (UICP) system to assist the Item Managers with decisions on when to buy, how much to buy, when to induct Not-Ready For Issue (NRFI) carcasses and how many to induct into the repair system. UICP is a fixed-order, continuous review inventory system.

Recent budget reductions have forced the NAVICP to find more cost-effective ways to manage spare parts with better customer service at a lower investment cost.

This thesis compares the current wholesale repairable inventory control process used by NAVICP to a proposed process based on the Bandwidth Management software program developed by a commercial company, (Stewart and Frazier, 1996). This is done by developing two simulation models, namely *UICP* and *BAND*. The simulations use the mean and standard deviation of the number of demands for certain repairable items identified by NAVICP, Code M051. The systems are compared using three formal measures of effectiveness (MOE's): Supply Material Availability (SMA), Average Delay for Delayed Requisitions (ADDR), and Average Monthly Investment Level (AMIL).

The *UICP* and *BAND* simulations assume the same repair process used by the current inventory control process. NRFI carcasses are periodically reviewed and inducted to the repair facility if the total number of available assets falls below the computed threshold level. The carcasses are inducted into repair in batches and returned as Ready for Issue (RFI) assets in batches. The repair level computed in *BAND* depends

only upon the expected number of carcasses that are received into the supply system and the number of those carcasses expected to be repaired and returned to the supply system as RFI assets for any given month.

The procurement process for the two systems is significantly different. The *UICP* simulation computes two decision variables. These variables represent how much to order and when to order (or reorder level). The reorder level is based upon the demand during an "average acquisition" time plus a safety level. An associated order quantity is computed based on the procurement cost, attrition demand, and related holding costs. A procurement action is initiated whenever the number of available assets falls below the reorder level. The quantity ordered is equal to the deficit below the reorder level plus the order quantity. At the end of each quarter, the demand is reforecast and the order quantity and reorder level are recomputed.

The *BAND* simulation computes a monthly delivery quantity as determined by a factor of the forecasted demand for each NIIN from the previous month. The product of the forecast demand and the wearout rate determines how many assets are required to replace those assets lost due to attrition.

## **B. CONCLUSIONS**

Statistics are collected from both simulations for all 240 items over a period of 600 months. The results are compared and analyzed for each measure of effectiveness. The results indicate that *BAND* does not perform as well as *UICP* in all three measures of effectiveness. Refer to Table 5.1.

Sensitivity analysis is performed on the results of all 240 items to determine whether selected groups of items can be managed more efficiently using the *BAND*

system. The items are divided into five categories based on the replacement cost. Although the **BAND** system performs better in one of the measures for three of the categories, it does not perform better than **UCIP**. Overall, **UCIP** is still considered a better inventory system for these 240 items.

An additional system **THIRD**, is developed as a variation of the **BAND** system. **THIRD** compares the existing number of backorders to all available RFI assets if the cumulative demand observations fall outside the bounds of the control band. If additional assets are required to fill existing backorders, the contractor is notified of this additional quantity and required to deliver them within two months.

The results indicate that **UCIP** also performs better than **THIRD** in all three measures of performance. Refer to Table 5.3.

### C. RECOMMENDATIONS

The **BAND** system does not appear to be a better inventory management tool for items with the same characteristics as those analyzed by the author. Therefore, it is recommended that NAVICP continue to use its existing inventory procedures. However, if the concept of regular deliveries continues to appeal to NAVICP, then further adaptations of **BAND** may be developed and compared.



## LIST OF REFERENCES

Bissinger, B.H. and Boyarski, J.R., "A Rank Correlation Approach for Trend Detection of Military Spare Parts Demand Data," Thirty-Sixth Conference on Design of Experiments, October 1990.

Bissinger, B.H. Functional Description (FD) for UICP Application D, Operation 01 (Levels), Rev 1, Appendix X, 01 March 1995.

Buss, A. and Stork, K. (1997). SIMKIT: A Toolkit for Simulation on the Internet, Operations Research Department, Naval Postgraduate School, Monterey, CA, [<http://algol.or.nps.navy.mil/~buss/papers/stork.pdf>].

Baker, S., Approximate Models for the Probability Distributions for Inventory Position and Net Inventory for Navy Repairable Items, Master's Thesis, Naval Postgraduate School, Monterey, California, 1994.

Department of Defense Instruction 4140.39, Procurement Cycles and Safety Levels of Supply for Secondary Items, 17 July 1970.

Flanagan, David, Java in a Nutshell, Second Edition, O'Reilly and Associates Inc., May 1997.

Hadley, G., and Whitin, T.M., Analysis of Inventory Systems, Prentice-Hall, Inc., 1963.

Horstmann, Cay S., and Cornell, Gary, Corejava 1.1: Volume I, Fundamentals, Sun Microsystems Inc., 1997.

Law, A.M., and Kelton, W. D., Simulation Modeling and Analysis, Second Edition, McGraw-Hill, Inc, 1991.

Maher, K. J., A Simulated Single-Item Aggregate Inventory Model for U.S. Navy Repairable Items, Master's Thesis, Naval Postgraduate School, Monterey, California, 1993.

McNertney, R, and Reynolds, K, Levels Setting Model Functional Description, FD-PD-82, Rev 2, 01 April 1993.

NAVICP ltr 5230, Ser M0418/284 dtd 17 Nov 1997, Statistical Summary Item Management Report of Navy Managed Interest Items for the Quarter Ending 30 Sept 97.

Robillard, G. C. , A Wholesale Level Consumable Item Inventory Model for Non-Stationary Demand Patterns, Master's Thesis, Naval Postgraduate School, Monterey, California, 1994.

Stewart, Dan and Frazier, Bob, S. (1996). S.F.T. Inc., Information on Bandwidth Management, [<http://www.catalog.com/sft/bndwmgmt.html>].

Tersine, R. J. Principles of Inventory and Materials Management, Fourth Edition, Prentice-Hall Inc., 1994.

United States Department of the Navy, Supply Systems Command, NAVSUP Publication 553, Inventory Management, January 1991.

Urban, A. and Maitland, R, Statistical Demand Forecasting Functional Description, FD-SDF, Rev1, Chg 0, 31 January, 1995.

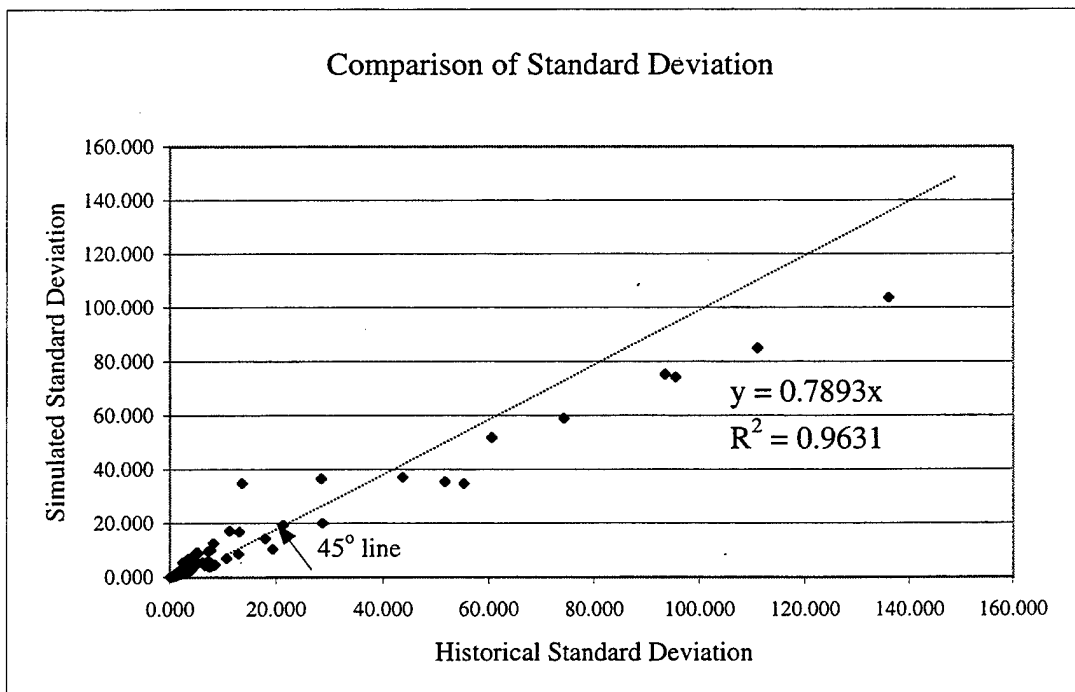
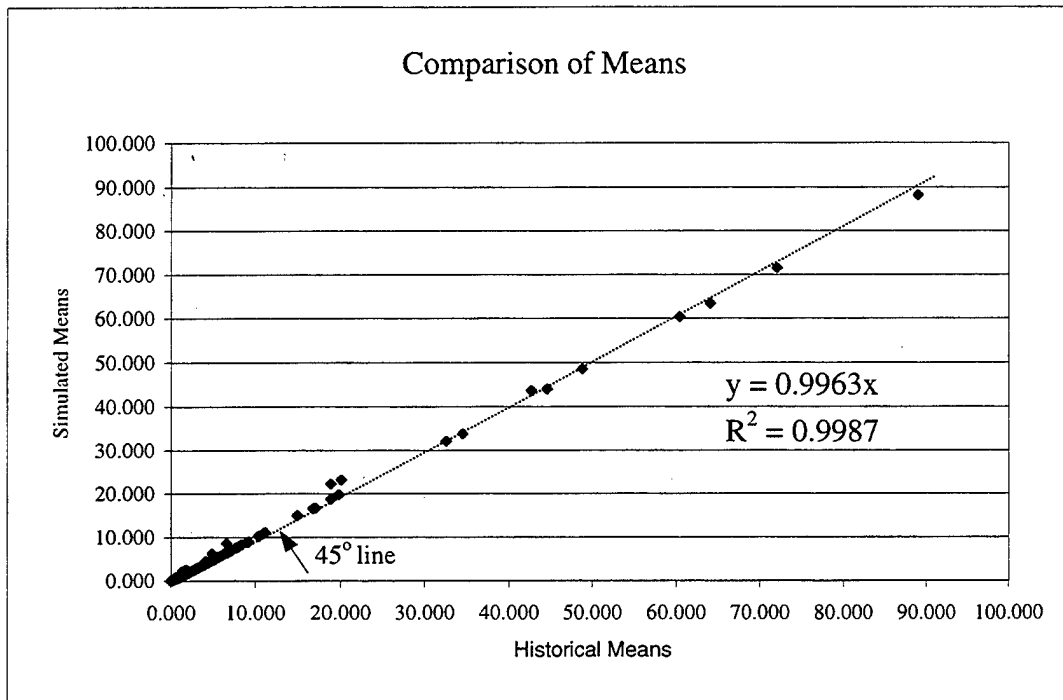
Urban, A., Forecasting LT/TAT Requirements Model, FD-PD-80, Rev 1, 31 December 1993.

**APPENDIX A: QUARTERLY MEAN AND STANDARD  
DEVIATION OF HISTORICAL DEMAND**

NIIN	Mean	SD	NIIN	Mean	SD	NIIN	Mean	SD
000805166	1.852	4.028	010157617	3.000	2.523	010501356	1.689	1.669
000805211	1.426	3.186	010157619	0.607	1.005	010501361	11.098	5.121
001024038	1.902	1.434	010166232	2.754	2.188	010501362	6.820	4.169
001053214	4.131	10.689	010166236	1.623	1.344	010501685	7.721	3.262
001110907	2.787	2.905	010256020	1.295	1.216	010507648	1.164	1.855
001115706	2.049	2.179	010263950	4.738	3.439	010515449	2.852	1.833
001122165	2.000	1.941	010263956	1.066	1.365	010521552	2.656	2.932
002185956	3.115	2.082	010263958	1.328	1.300	010543301	2.820	1.945
003172349	1.787	1.808	010263961	2.180	2.232	010603341	1.000	2.168
004766898	3.230	2.698	010263963	1.148	1.249	010603344	2.902	2.625
005557358	1.984	2.125	010300091	5.148	6.156	010603348	5.639	7.264
005557414	18.869	13.063	010317639	2.787	1.762	010624141	1.262	1.139
005557906	0.738	1.109	010328875	1.541	1.433	010628605	7.852	4.126
005759297	19.803	11.260	010329624	2.508	2.079	010629351	1.115	1.603
005966273	1.475	1.738	010329693	1.820	1.618	010629365	5.541	4.766
005966274	1.393	1.744	010329694	1.787	1.863	010640485	10.459	7.201
005966475	1.410	1.321	010337454	1.672	1.964	010658297	32.557	43.745
006011040	1.230	1.309	010380313	1.902	2.071	010670473	2.279	2.199
006011236	5.623	3.861	010395544	10.328	5.306	010684706	1.475	1.545
006011294	2.754	3.176	010395549	2.656	2.522	010685010	1.377	1.267
006011365	2.852	2.023	010395551	3.803	3.229	010691903	1.869	1.431
006011412	5.885	3.498	010395555	2.934	2.120	010694631	4.016	2.952
006011423	3.689	2.514	010395556	1.164	1.143	010694632	4.525	3.075
006011563	0.803	1.014	010395580	1.295	1.216	010761346	3.885	2.229
006026779	1.639	3.115	010395592	42.639	13.588	010875292	1.770	8.510
006026786	1.475	3.238	010395593	2.967	2.302	010881426	7.082	3.989
006026815	2.492	1.776	010400355	2.607	2.525	010898895	14.951	8.221
006026823	2.951	2.783	010402651	1.754	1.491	010914361	3.902	3.037
006026836	3.492	2.925	010466624	1.082	1.358	010931283	89.016	136.080
006137235	6.574	12.941	010466662	1.016	1.103	010931372	8.361	3.455
006137243	1.328	2.862	010466666	1.885	1.404	010931468	4.951	2.765
006137244	1.525	2.919	010466703	1.443	1.467	010942520	6.213	4.148
006137245	5.885	3.251	010466711	1.459	1.747	010942577	1.754	1.629
008707009	1.377	1.199	010474930	3.557	2.013	010942819	4.131	2.723
009460294	3.361	3.416	010474977	2.377	2.185	010992869	0.984	1.258
010036797	6.426	2.411	010474978	1.082	0.988	010992871	1.508	1.680
010066270	1.049	1.477	010475007	4.410	2.837	011000306	1.541	1.608
010090517	0.672	2.386	010475018	1.951	2.202	011026824	6.475	3.365
010157346	1.574	3.025	010475020	1.820	1.747	011029486	1.311	1.285
010157451	6.607	18.000	010484634	1.098	1.028	011110558	16.803	28.672
010157615	5.508	3.654	010484647	1.180	1.555	011167167	0.918	1.173

NIIN	Mean	SD	NIIN	Mean	SD	NIIN	Mean	SD
011167313	20.082	51.777	012050364	1.443	1.133	013456651	0.164	0.454
011172219	2.918	2.178	012050427	1.262	1.237	013527033	1.148	2.112
011175564	18.869	55.315	012050456	1.246	1.374	013529965	1.344	7.648
011179931	2.934	2.774	012050795	0.721	0.933	013544801	0.705	1.145
011285343	3.885	2.450	012050797	1.689	1.597	013622920	1.377	1.968
011305743	3.705	2.383	012050799	1.492	1.649	013722789	0.820	1.336
011306050	0.951	1.175	012050871	2.738	2.523	013731805	0.656	2.938
011306053	2.033	1.751	012057064	6.639	3.573	013731806	1.508	3.990
011346899	4.279	2.517	012137310	2.787	2.042	013758841	0.820	2.054
011349738	0.197	0.440	012186385	2.000	1.683	013904835	1.721	4.079
011349739	8.951	4.334	012186392	4.148	2.522	013909323	0.902	2.378
011349740	0.393	0.802	012194678	2.230	2.334	013909324	0.426	1.040
011349756	4.295	2.759	012201789	0.967	1.224	013912116	1.033	2.442
011356458	6.738	3.885	012294506	1.180	1.190	013914402	0.443	0.940
011368496	2.590	1.697	012394886	3.279	3.629	013957062	1.016	2.187
011380217	2.115	4.038	012411959	3.803	2.414	013985356	0.033	0.180
011380224	0.803	1.481	012479676	1.115	1.550	014064382	0.016	0.128
011428662	1.607	1.574	012524331	2.672	2.650	014074576	0.066	0.309
011483400	2.230	1.667	012675048	1.951	1.755	014074634	1.639	3.077
011498996	72.066	111.037	012675068	2.082	2.319	014108253	0.197	0.853
011498997	64.033	93.493	012763958	0.639	0.797	014185119	0.033	0.256
011498998	60.426	95.493	012810084	1.131	1.688	014221181	0.164	0.454
011498999	48.820	74.201	012829008	0.541	3.128	014225114	0.426	1.500
011499000	44.492	60.545	012829115	1.328	1.886	014341799	0.180	0.742
011540787	4.033	2.763	012858138	3.770	3.185	014404503	0.180	0.619
011688323	1.197	1.662	012864787	3.230	3.607	014458185	0.033	0.256
011720712	4.607	3.537	012864789	0.885	1.644	014466681	0.033	0.180
011744277	0.934	1.109	012944162	4.869	19.348	150685523	1.852	1.851
011744278	2.197	1.824	013048188	1.721	1.984	150685525	17.049	21.370
011744279	1.066	1.377	013086683	1.361	1.798	150685585	9.197	7.652
011744280	0.787	1.674	013117486	34.525	28.422	151004675	1.443	2.527
011744281	1.738	1.377	013145858	1.164	1.614	151117580	1.295	1.909
011744307	3.754	6.567	013149207	0.836	1.083	997356301	0.230	1.296
011769828	1.541	2.699	013178331	1.607	1.706	997401343	1.770	2.597
011838164	2.246	1.823	013182610	5.475	3.594	998919977	1.852	7.245
011863377	1.492	1.649	013186355	1.738	1.897			
011875033	0.295	1.022	013311678	0.934	1.263			
011875041	2.705	1.969	013382285	0.475	0.788			
011875188	1.262	1.788	013397935	0.902	2.897			
011893072	2.918	1.969	013451504	1.639	2.569			
012034772	4.328	4.697	013456650	0.361	0.684			

## APPENDIX B. GRAPHICAL COMPARISON OF HISTORICAL AND SIMULATED MONTHLY MEANS AND STANDARD DEVIATIONS





## APPENDIX C. INPUT PARAMETERS FOR *UICP* AND *BAND*

### 1. The following parameters are common to both *UICP* and *BAND*:

National Item Identification Number (NIIN). A unique nine character code assigned to each item of supply purchased, stocked or distributed within the Federal Government.

Average Quarterly Demand (M). The average quarterly demand as determined by 60 months of historical demand data.

Standard Deviation (SD). The associated standard deviation of the quarterly demand as determined by 60 months of historical demand data.

Length of Simulation Run. Length of time the simulation runs in terms of months.

Carcass Return Rate (CRR). The percentage of the total demands that a carcass can be expected to be turned in for repair.

Repair Survival Rate (RSR). The percentage of items inducted into the repair program that can be anticipated to be repaired and returned to a useable or serviceable condition.

Repair Turnaround Time (RTAT). Measured from the time a NRFI carcass is inducted into the repair system (changes from condition code F to M) until it is successfully repaired and returned to RFI condition (from M to A condition).

Procurement Lead-time (PCLT). The length of time from the generation of a procurement action until the initial receipt of material from contract. The sum of ALT and PLT.

Cost to Repair (CTR). The cost to the depot for repairing a NRFI carcass.

### 2. The following parameters are specific to *UICP*:

Forecasted Demand (D). The forecasted demand for the upcoming quarter based on 60 months of historical demand data and determined using exponential smoothing ( $\alpha = 0.1$ ).

Forecasted Mean Absolute Deviation of Demand (MAD). Computed using the 60 months of historical demand data and determined using exponential smoothing ( $\alpha = 0.1$ ).

Navy Repair Turnaround Time MAD (rMAD). MAD for the Repair Turnaround Time based on historical data from Navy repair depots. Used to compute the Repair Turnaround Time variance for Navy repaired items.

Commercial Repair Turnaround Time (cMAD). MAD for the Repair Turnaround Time based on historical data from commercial repair depots. Used to compute the Repair Turnaround Time variance for commercially repaired items.

Procurement Lead Time (pMAD). MAD for the Procurement Lead Time based on historical data from commercial companies. Used to compute the Repair Turnaround Time variance for commercially procured items.

Lead Time Demand (ITD). Demand during lead time based on historical demand data for that item.

Shortage Cost (SC). The cost associated with placing a customer request (demand) for material on backorder.

Unit Price (UP). The replacement cost of an item.

Average Requisition Quantity (RQFRO). Average number of requisitions per order for that item based on historical data.

Safety Level Constraint ( $K_1$ ). NAVICP-set value to ensure the safety level and reorder level does not fall below a  $(1-K_1)$  percentage of the Procurement Problem Variable.

National Stocking Objective (NSO). NAVICP-set value for low demand items to ensure a minimum stockage level (usually one).

Rules Code (R). NAVICP code used to identify whether the item is repaired commercially or by the Navy.

Shelf Life (SL). The number of months the item is allowed to sit on the shelf and still be considered a useable asset.

**3. The following parameter is specific to *BAND*:**

Confidence Interval for Control Band (CI). The number of standard deviations above and below the mean. Used to compute the upper and lower control bands.

## APPENDIX D. VARIABLES AND CONSTANTS

### Variables:

$\hat{R}$ :	Constrained reorder level.
$\hat{Q}$ :	Constrained order quantity.
$\hat{R}_2$ :	Constrained repair level.
$\sigma_{DLR}$ :	Standard Deviation of demand during lead time.
AA:	Total number of potential assets available to fill demands. Applicable to the <b>UICP</b> system when determining if carcasses should be shipped to the repairing facility.
ASSETS:	Total number of potential assets available to fill demands. Applicable to the <b>BAND</b> system when determining if carcasses should be shipped to the repairing facility.
AVAILASSETS:	Total number of potential assets available to fill demands. Applicable to the <b>THIRD</b> system when determining if additional assets are required to fill backorders. This order is in addition to the monthly delivery quantity.
Backorder:	Number of demands in backorder at a specific period in time.
D:	Forecast demand for upcoming period.
DELQTY:	Monthly delivery quantity provided by the contractor. Applicable to the <b>BAND</b> system.
D-G:	Attrition demand. Those demands that did not an accompanying carcass or that could not be repaired by the repair facility.
G:	Number of demands that can be repaired and returned to wholesale stock.
IP:	Inventory position. All assets potentially available to fill demands. Used when determining if an order is needed in the <b>UICP</b> system.
MAD:	Mean Absolute Deviation of demand.
On-hand:	Number of assets on-hand in wholesale stock.
On-order:	Number of items on order that are due into wholesale stock within a procurement lead time.

PPVV: Procurement Problem Variable Variance. The variance associated with the demand during lead time.

Q: Unconstrained order quantity for the quarter.

REPAIRLEVEL: Threshold value used in **BAND** system to determine if carcasses need to be shipped to the repair facility.

RFI Due-in: The number of repaired assets due in within the next month. Associated with the **BAND** system.

RISK: Probability that a stockout will occur.

t: Standard Normal deviate associated with the probability of a stockout (RISK).

Z: Procurement Problem Variable. Net demand during lead time that cannot be filled with regenerated carcasses.

$Z_2$  Net demand during an RTAT.

**Constants:**

$\lambda$ : Shortage Cost per requisition.

A: Administrative cost associated with an order.

C: Unit price of an item.

$C_2$ : Cost to repair one item.

CRR: Carcass Return Rate. The probability that a failed item will accompany a demand.

E: Mission Essentiality Code of the item.

F: Forecast demand/average requisition size.

H: Shelf life of the item.

I: Variable holding rate associated with holding an item in stock.

$K_0$  NAVICP-set value to ensure the minimum order quantity is at least one.

$K_1$  NAVICP-set value to ensure the safety level and reorder level do not fall below a  $(1-K_1)$  percentage of the Procurement Problem Variable.

L:	Time interval beginning with the placement of an order and ending with the receipt of that order into wholesale stock. Also referred to as PCLT.
NSO:	NAVICP-set value for low demand items to ensure a minimum stockage level.
PCLT:	Time interval beginning with the placement of an order and ending with the receipt of that order into wholesale stock. Also referred to as L.
RSR:	Repair Survival Rate. The probability that a repair facility can repair an item.
RTAT:	Repair Turnaround Time. Time interval beginning with the receipt of NRFI carcasses by the repair facility to the time they are returned to the system as RFI assets.
T:	Repair Cycle Time. Equal to one RTAT plus the time between repair cycles (0.19 quarters).
W:	Wearout rate. $(1 - \text{CRR} * \text{RSR})$



## **APPENDIX E. DEFINITIONS OF HEADINGS FOR DATA RESULTS**

NIIN:	REPAIRABLE ITEM BEING ANALYZED.
ISSUES:	NUMBER OF FIRST TIME ISSUES FOR THAT ITEM DURING THE 601 MONTHS.
DMDS:	NUMBER OF TOTAL DEMANDS FOR THAT ITEM DURING THE 601 MONTHS.
B/O'S:	TOTAL NUMBER OF BACKORDERS FOR THAT ITEM DURING THE 601 MONTHS
TIME IN B/O:	CUMULATIVE TIME THAT EACH DEMAND REMAINED IN BACKORDER FOR THE 601 MONTHS.
AVG TIME:	TIME IN B/O DIVIDED BY B/O'S.
AVG INV LEVEL:	AVERAGE NUMBER OF ITEMS IN STOCK PER MONTH FOR THE 601 MONTHS.
U/P REPL:	COST TO NAVICP TO REPLACE ITEM FROM COMMERCIAL SOURCE.
HOLD RT.	HOLDING RATE AS DISCUSSED IN THESIS IN TERMS OF MONTHLY COST.
HOLD CST:	COST TO HOLD INVENTORY PER MONTH. (AVG INV LEVEL * U/P REPL * HOLD RT).



**APPENDIX F. ASSOCIATED VALUES FOR FACTORS KEPT  
CONSTANT IN SIMULATION**

NIIN	CRR	RSR	RTAT	NIIN	CRR	RSR	RTAT	NIIN	CRR	RSR	RTAT
	qtrs	qtrs	qtrs		qtrs	qtrs	qtrs		qtrs	qtrs	qtrs
000805166	1.00	0.85	2.62	010157619	1.00	1.00	0.43	010501362	0.97	0.93	2.77
000805211	1.00	0.85	2.62	010166232	1.00	0.95	0.68	010501685	0.97	0.88	0.73
001024038	0.98	1.00	1.35	010166236	1.00	1.00	0.65	010507648	1.00	1.00	0.35
001053214	1.00	1.00	0.87	010256020	0.97	1.00	0.35	010515449	0.97	1.00	1.84
001110907	1.00	1.00	0.49	010263950	1.00	0.87	0.5	010521552	1.00	0.76	2.75
001115706	1.00	0.76	1.54	010263956	1.00	0.88	0.7	010543301	0.80	1.00	0.99
001122165	1.00	0.45	1	010263958	0.97	1.00	0.89	010603341	0.93	1.00	0.69
002185956	1.00	1.00	2.19	010263961	1.00	0.86	0.61	010603344	0.96	1.00	0.11
003172349	0.95	0.82	1.66	010263963	1.00	0.86	0.48	010603348	1.00	0.95	0.24
004766898	1.00	0.80	2.89	010300091	0.97	0.98	1.65	010624141	0.99	0.91	1.2
005557358	0.98	1.00	0.3	010317639	1.00	1.00	1.17	010628605	1.00	0.88	0.64
005557414	1.00	0.76	1	010328875	1.00	0.85	1.4	010629351	0.77	0.82	2.94
005557906	1.00	0.82	0.93	010329624	1.00	1.00	0.37	010629365	1.00	0.97	0.31
005759297	0.84	0.95	1.5	010329693	1.00	0.85	0.42	010640485	0.98	1.00	1.61
005966273	0.95	0.55	0.46	010329694	1.00	1.00	1.02	010658297	1.00	0.60	2.07
005966274	1.00	0.55	0.57	010337454	0.91	0.90	0.96	010670473	0.98	0.81	0.65
005966475	1.00	0.85	0.86	010380313	1.00	0.95	1.15	010684706	1.00	0.95	1.17
006011040	1.00	0.85	0.86	010395544	0.98	0.99	0.23	010685010	1.00	1.00	2.71
006011236	0.99	0.90	0.52	010395549	1.00	1.00	1.13	010691903	0.97	0.95	0.99
006011294	1.00	0.72	0.29	010395551	1.00	0.98	1.07	010694631	0.99	1.00	0.27
006011365	0.95	0.85	1.47	010395555	1.00	0.82	0.85	010694632	0.99	1.00	0.35
006011412	1.00	0.30	0.37	010395556	0.98	0.85	0.85	010761346	1.00	0.96	0.83
006011423	0.94	0.48	0.2	010395580	1.00	1.00	0.31	010875292	1.00	0.95	2.23
006011563	1.00	0.93	1.15	010395592	1.00	1.00	0.22	010881426	1.00	0.98	0.86
006026779	0.96	0.80	0.5	010395593	1.00	0.92	0.85	010898895	0.99	0.85	2.22
006026786	0.97	0.89	0.56	010400355	0.98	1.00	0.66	010914361	0.99	1.00	1.69
006026815	0.86	1.00	0.25	010402651	0.98	1.00	0.92	010931283	1.00	0.85	1.32
006026823	1.00	0.95	0.39	010466624	0.97	0.93	1.75	010931372	0.99	1.00	0.36
006026836	1.00	0.95	0.22	010466662	0.97	0.90	0.88	010931468	0.99	0.89	1.49
006137235	1.00	0.92	1.04	010466666	0.98	1.00	0.43	010942520	1.00	1.00	1.04
006137243	1.00	0.87	1.9	010466703	1.00	1.00	0.7	010942577	1.00	0.92	1.25
006137244	1.00	0.96	0.75	010466711	1.00	1.00	0.93	010942819	1.00	0.90	0.77
006137245	1.00	0.95	1.64	010474930	0.99	1.00	0.93	010992869	0.92	0.61	1.22
008707009	1.00	1.00	2.14	010474977	1.00	1.00	1.05	010992871	0.98	1.00	0.84
009460294	1.00	0.76	0.99	010474978	1.00	1.00	2.78	011000306	1.00	1.00	2.38
010036797	0.98	0.85	1.79	010475007	1.00	0.95	0.27	011026824	1.00	0.85	2.18
010066270	1.00	0.85	0.86	010475018	1.00	1.00	1.04	011029486	1.00	0.92	0.5
010090517	0.96	0.85	1.7	010475020	1.00	0.98	1.35	011110558	1.00	1.00	1.81
010157346	0.85	0.72	0.96	010484634	1.00	1.00	0.59	011167167	1.00	1.00	0.58
010157451	0.99	0.85	1.7	010484647	1.00	1.00	0.67	011167313	0.99	0.85	1.7
010157615	0.95	1.00	0.52	010501356	0.98	0.64	0.52	011172219	0.99	1.00	1.98

010157617	0.91	1.00	0.28	010501361	1.00	0.96	0.52	011175564	0.99	0.85	1.7
<b>NIIN</b>	<b>CRR</b>	<b>RSR</b>	<b>RTAT</b>	<b>NIIN</b>	<b>CRR</b>	<b>RSR</b>	<b>RTAT</b>	<b>NIIN</b>	<b>CRR</b>	<b>RSR</b>	<b>RTAT</b>
	<b>qtrs</b>	<b>qtrs</b>	<b>qtrs</b>		<b>qtrs</b>	<b>qtrs</b>	<b>qtrs</b>		<b>qtrs</b>	<b>qtrs</b>	<b>qtrs</b>
011179931	1.00	0.99	1.44	012050797	1.00	0.99	2.18	013722789	1.00	0.92	0.87
011285343	1.00	1.00	2	012050799	1.00	0.98	0.22	013731805	1.00	0.92	0.86
011305743	0.98	0.86	1.32	012050871	1.00	1.00	1.9	013731806	0.93	0.92	0.86
011306050	0.87	0.85	1.5	012057064	0.99	1.00	0.88	013758841	1.00	0.92	1.07
011306053	1.00	0.85	1.93	012137310	0.95	0.84	1.39	013904835	0.97	0.92	0.83
011346899	0.98	1.00	1.78	012186385	1.00	1.00	1.04	013909323	0.97	0.92	0.88
011349738	1.00	0.84	1.21	012186392	0.97	0.78	2.5	013909324	0.97	0.92	1.05
011349739	1.00	0.96	1.3	012194678	1.00	0.92	2.16	013912116	0.97	0.92	1.01
011349740	1.00	0.85	0.44	012201789	1.00	1.00	1.78	013914402	0.97	0.92	1.1
011349756	1.00	0.94	1.35	012294506	0.98	0.63	0.26	013957062	1.00	0.60	0.73
011356458	0.99	1.00	1.18	012394886	0.99	1.00	0.54	013985356	0.97	0.92	1.36
011368496	0.96	0.98	0.54	012411959	0.98	1.00	0.59	014064382	0.97	0.92	1.36
011380217	1.00	0.58	1.1	012479676	1.00	1.00	1.36	014074576	0.97	0.92	1.36
011380224	1.00	0.85	0.85	012524331	0.99	0.96	0.55	014074634	1.00	0.92	0.88
011428662	1.00	0.90	0.83	012675048	1.00	0.92	2.42	014108253	0.97	0.92	1.36
011483400	1.00	1.00	0.85	012675068	1.00	0.92	0.85	014185119	0.97	0.92	1.11
011498996	1.00	0.85	0.86	012763958	1.00	0.36	0.8	014221181	0.97	0.92	0.35
011498997	1.00	0.85	0.86	012810084	1.00	0.85	1.37	014225114	0.97	0.92	1.33
011498998	1.00	0.85	0.86	012829008	1.00	0.92	0.86	014341799	0.97	0.92	0.96
011498999	1.00	0.85	0.86	012829115	1.00	0.92	1.36	014404503	0.97	0.92	0.85
011499000	1.00	0.85	0.86	012858138	1.00	0.92	1.86	014458185	0.93	0.92	0.96
011540787	1.00	0.98	0.45	012864787	1.00	0.92	2.44	014466681	0.93	0.92	0.96
011688323	1.00	0.93	1.5	012864789	1.00	0.92	2.05	150685523	1.00	0.73	1.3
011720712	0.99	1.00	0.92	012944162	1.00	0.10	0.86	150685525	0.00	0.00	0
011744277	1.00	0.89	0.99	013048188	0.97	1.00	0.99	150685585	1.00	0.46	1.39
011744278	1.00	0.90	0.99	013086683	1.00	0.92	1.36	151004675	0.00	0.00	0
011744279	1.00	0.90	0.99	013117486	1.00	0.92	2.41	151117580	0.00	0.00	0
011744280	1.00	0.90	0.99	013145858	0.97	0.92	1.19	997356301	0.93	0.92	0.87
011744281	0.99	0.90	0.99	013149207	0.90	1.00	1.21	997401343	1.00	0.92	1.25
011744307	1.00	1.00	1.2	013178331	1.00	0.85	0.87	998919977	1.00	0.92	0.87
011769828	1.00	1.00	1.48	013182610	1.00	0.85	1.64				
011838164	0.98	0.95	0.78	013186355	1.00	0.85	2.1				
011863377	0.94	0.68	0.59	013311678	1.00	0.85	1.8				
011875033	1.00	0.90	0.99	013382285	1.00	0.92	1.97				
011875041	0.98	1.00	1.25	013397935	1.00	0.92	1.25				
011875188	0.93	0.90	0.87	013451504	1.00	0.92	0.85				
011893072	1.00	0.85	1.36	013456650	0.93	0.92	1.2				
012034772	1.00	0.95	1.92	013456651	0.93	0.92	1				
012050364	1.00	1.00	2.53	013527033	0.99	0.85	1.15				
012050427	1.00	1.00	2.32	013529965	0.93	0.92	0.87				
012050456	1.00	0.92	2.36	013544801	1.00	0.92	3				
012050795	0.64	0.78	0.6	013622920	0.96	0.77	2				

# APPENDIX G. DATA RESULTS FROM UICP

NIIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level (Per Month)	U/P Repl	Hold Rt (.21/12)	Hld Cst
000805166	1021	1363	0.749	342	29168.75048	85.289	13.42843091	3450.00	0.0175	\$810.74
000805211	879	1039	0.846	160	8507.084467	53.169	10.89886674	3037.86	53.16255	\$579.41
001024038	776	946	0.820	170	3594.750958	21.146	4.126969298	2067.81	36.186675	\$149.34
001053214	2994	3662	0.818	668	17174.84538	25.711	23.08077525	767.94	13.43895	\$310.18
001110907	1091	1562	0.698	474	7203.610904	15.197	4.046471105	1537.80	26.9115	\$108.90
001115706	1056	1058	0.998	2	24.31730655	12.159	13.6872567	491.54	8.60195	\$117.74
001122165	1038	1077	0.964	39	1518.319187	38.931	12.58692071	1015.68	17.7744	\$223.72
002185956	1410	1696	0.831	286	7565.279629	26.452	6.383205358	6346.00	111.055	\$708.89
003172349	852	893	0.954	41	900.3317037	21.959	8.158271426	1746.00	30.555	\$249.28
004766898	1555	1722	0.903	167	5877.610982	35.195	10.64836497	3073.77	53.790975	\$572.79
005557358	843	1055	0.799	212	2585.263309	12.195	2.555376763	4134.25	72.349375	\$184.88
005557414	8538	11429	0.747	2924	45724.70314	15.638	25.92949397	2747.76	48.0858	\$1,246.84
005557906	354	354	1.000	0	0	0.000	6.159166301	11650.99	203.892325	\$1,255.81
005759297	7437	11285	0.659	3857	99630.77593	25.831	27.17999141	1620.72	28.3626	\$770.90
005966273	701	733	0.956	32	454.5414839	14.204	5.333356826	2081.00	36.4175	\$194.23
005966274	698	728	0.959	30	384.7188371	12.824	5.7962434	2084.00	36.47	\$211.39
005966475	609	609	1.000	0	0	0.000	8.664323932	1260.59	22.060325	\$191.14
006011040	568	568	1.000	0	0	0.000	7.834606192	883.00	15.4525	\$121.06
006011236	2525	3138	0.805	613	7068.591268	11.531	6.550897443	1947.84	34.0872	\$223.30
006011294	1303	1492	0.873	189	2072.25352	10.964	7.159377446	484.92	8.4861	\$60.76
006011365	1465	1487	0.985	22	255.2083907	11.600	11.54988588	1519.40	26.5895	\$307.11
006011412	3398	3463	0.981	65	698.0235518	10.739	21.95412096	1005.96	17.6043	\$386.49
006011423	1954	2011	0.972	57	1456.286982	25.549	10.99064742	819.00	14.3325	\$157.52
006011563	340	340	1.000	0	0	0.000	4.848580068	1453.69	25.439575	\$123.35
006026779	944	1113	0.848	169	2826.879047	16.727	5.426503473	2076.00	36.33	\$197.14
006026786	900	1108	0.812	208	3875.24731	18.631	4.984068757	1559.00	27.2825	\$135.98
006026815	1152	1273	0.905	121	1061.649448	8.774	3.203677564	2517.70	44.05975	\$141.15
006026823	1343	1719	0.781	376	4491.126882	11.944	3.891624583	1257.00	21.9975	\$85.61
006026836	1589	1897	0.838	308	2580.625971	8.379	3.727992706	878.35	15.371125	\$57.30
006137235	4426	5124	0.864	679	21158.86696	31.162	30.67845502	821.23	14.371525	\$440.90
006137243	821	1023	0.803	205	10994.07323	53.630	6.832169813	20590.72	360.3376	\$2,461.89
006137244	698	991	0.704	293	8208.355283	28.015	3.656486434	6707.00	117.3725	\$429.17
006137245	2675	3269	0.818	594	11787.67958	19.845	8.786808048	5165.00	90.3875	\$794.21
008707009	601	613	0.980	12	230.0887653	19.174	5.372149694	12213.50	213.73625	\$1,148.22
009460294	1873	1973	0.949	100	1510.924698	15.109	12.93197687	1242.00	21.735	\$281.08
010036797	3313	3581	0.925	268	2300.9154	8.586	10.35951346	3647.77	63.835975	\$661.31
010066270	468	526	0.890	58	1397.505246	24.095	3.303844809	9597.39	167.954325	\$554.90
010090517	658	678	0.971	20	394.3589591	0.000	16.92752367	649.00	11.3575	\$192.25
010157346	953	1170	0.815	217	7453.707264	34.349	6.874710008	11450.00	200.375	\$1,377.52
010157451	5665	6554	0.864	889	36876.31826	41.481	64.89523926	1449.36	25.3638	\$1,645.99
010157615	2300	3073	0.748	773	9980.024693	12.911	5.730528152	1154.99	20.212325	\$115.83
010157617	1364	1653	0.825	289	2684.301108	9.288	3.933226422	1378.00	24.115	\$94.85
010157619	278	278	1.000	0	0	0.000	3.55836744	655.77	11.475975	\$40.84
010166232	1121	1443	0.777	323	4609.976502	14.272	4.275893072	780.55	13.659625	\$58.41

NTIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level	U/P	Repl	Hold Rt (.21/12)	Hld Cst
010166236	700	763	0.917	63	1128.829328	17.918	3.382120692	720.94		12.61645	\$42.67
010256020	584	621	0.940	37	429.8275707	11.617	3.053647016	886.74		15.51795	\$47.39
010263950	2005	2623	0.764	618	8494.512374	13.745	6.221517448	580.00		10.15	\$63.15
010263956	482	503	0.958	21	253.5498804	12.074	3.393520478	871.38		15.24915	\$51.75
010263958	501	584	0.858	83	1941.102846	23.387	2.570031951	528.16		9.2428	\$23.75
010263961	1048	1203	0.871	155	2465.14977	15.904	4.109834713	871.00		15.2425	\$62.64
010263963	525	530	0.991	5	67.18383055	13.437	5.185859636	501.00		8.7675	\$45.47
010300091	2211	3349	0.660	1138	46272.33569	40.661	10.97611069	876.49		15.338575	\$168.36
010317639	1247	1384	0.901	137	2359.439322	17.222	4.794872357	35050.00		613.375	\$2,941.05
010328875	667	735	0.907	68	1860.596541	27.362	5.089391278	2283.00		39.9525	\$203.33
010329624	1026	1251	0.820	225	2287.063434	10.165	2.897097996	539.21		9.436175	\$27.34
010329693	815	900	0.906	85	1093.760788	12.868	3.503507232	544.90		9.53575	\$33.41
010329694	752	903	0.833	151	3798.107386	25.153	4.194984329	2188.90		38.30575	\$160.69
010337454	903	968	0.933	65	1138.734968	17.519	5.035491527	795.83		13.927025	\$70.13
010380313	1004	1040	0.965	36	671.1355258	18.643	8.175621951	707.95		12.389125	\$101.29
010395544	4249	5955	0.714	1705	11522.55547	6.758	5.990921302	830.00		14.525	\$87.02
010395549	1134	1469	0.772	330	7825.629164	23.714	5.508365986	462.00		8.085	\$44.54
010395551	1554	2074	0.749	523	12977.63037	24.814	5.464943263	889.53		15.566775	\$85.07
010395555	1340	1593	0.841	253	3798.987391	15.016	5.411500234	801.00		14.0175	\$75.86
010395556	457	462	0.989	5	80.17511655	16.035	6.702721491	544.00		9.52	\$63.81
010395580	576	587	0.981	11	109.8980227	9.991	3.953395283	544.35		9.526125	\$37.66
010395592	12549	25640	0.489	13127	82363.32088	6.274	16.62416619	850.00		14.875	\$247.28
010395593	1333	1605	0.831	271	4317.032632	15.930	4.858987729	643.00		11.2525	\$54.68
010400355	1017	1415	0.719	398	7231.857911	18.170	3.882337594	950.07		16.626225	\$64.55
010402651	761	823	0.925	62	1150.374959	18.554	3.780988297	703.24		12.3067	\$46.53
010466624	485	509	0.953	25	517.6591544	20.706	5.466209945	6925.00		121.1875	\$662.44
010466662	399	438	0.911	39	855.8468019	21.945	3.373453066	4300.00		75.25	\$253.85
010466666	814	914	0.891	100	971.2760649	9.713	2.738141161	6714.00		117.495	\$321.72
010466703	637	670	0.951	33	889.3144049	26.949	4.351855044	905.37		15.843975	\$68.95
010466711	688	757	0.909	69	1994.632859	28.908	5.62697277	1601.54		28.02695	\$157.71
010474930	1498	1842	0.813	343	5225.001955	15.233	4.519268794	6492.00		113.61	\$513.43
010474977	893	1192	0.749	299	7824.149961	26.168	3.977900315	677.16		11.8503	\$47.14
010474978	398	425	0.936	27	1254.913006	46.478	7.819631846	2059.00		36.0325	\$281.76
010475007	2056	2475	0.831	419	3162.572633	7.548	3.86826254	617.55		10.807125	\$41.80
010475018	794	1098	0.723	304	8387.07965	27.589	3.843211469	1238.82		21.67935	\$83.32
010475020	770	871	0.884	100	2548.286075	25.483	4.069845382	758.20		13.2685	\$54.00
010484634	380	436	0.872	56	931.2134069	16.629	1.859220443	1564.00		27.37	\$50.89
010484647	485	585	0.829	100	1876.456625	18.765	3.214096334	1723.17		30.155475	\$96.92
010501356	801	845	0.948	44	448.6167006	10.196	5.226516912	2034.00		35.595	\$186.04
010501361	5046	6456	0.782	1410	12583.66036	8.925	8.472653536	2687.00		47.0225	\$398.41
010501362	3219	3999	0.805	780	23842.80876	30.568	13.92964578	2622.84		45.8997	\$639.37
010501685	3741	4299	0.870	561	5166.888524	9.210	7.928736872	2815.78		49.27615	\$390.70
010507648	628	636	0.987	8	41.7651239	5.221	5.643053948	1600.00		28	\$158.01
010515449	1397	1468	0.952	71	1108.134127	15.608	11.93500748	3100.00		54.25	\$647.47
010521552	1434	1597	0.898	163	6407.246514	39.308	13.19278775	1092.00		19.11	\$252.11

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010543301	1281	1495	0.857	214	4580.75527	21.405	5.862925334	72982.00		1277.185	\$7,488.04
010603341	646	693	0.932	47	686.9291317	14.616	5.567171448	672.50		11.76875	\$65.52
010603344	1257	1562	0.805	305	1945.505417	6.379	2.267376471	537.30		9.40275	\$21.32
010603348	2074	3701	0.560	1627	19369.79169	11.905	5.754531351	474.11		8.296925	\$47.74
010624141	510	565	0.903	55	2050.86279	37.288	4.566868688	12228.00		213.99	\$977.23
010628605	3487	4436	0.786	949	10836.78431	11.419	7.930690199	392.00		6.86	\$54.40
010629351	559	559	1.000	0	0	0.000	12.37091109	2600.60		45.5105	\$563.01
010629365	2716	3303	0.822	587	4573.502846	7.791	7.163033633	539.31		9.437925	\$67.60
010640485	4692	5839	0.804	1147	23591.68614	20.568	17.82224245	698.58		12.22515	\$217.88
010658297	13977	22504	0.621	8527	461307.2029	54.100	101.2114005	611.71		10.704925	\$1,083.46
010670473	1076	1235	0.871	162	2937.367016	18.132	4.498636975	1326.00		23.205	\$104.39
010684706	608	691	0.880	83	1782.614512	21.477	3.037792324	4547.00		79.5725	\$241.72
010685010	610	633	0.964	23	430.987147	18.739	6.275209148	8571.66		150.00405	\$941.31
010691903	854	870	0.982	16	208.1434692	13.009	5.824563118	3295.00		57.6625	\$335.86
010694631	1548	2085	0.742	537	5166.257164	9.621	3.253413671	5464.00		95.62	\$311.09
010694632	1997	2515	0.794	520	5229.897421	10.057	4.429492183	4691.00		82.0925	\$363.63
010761346	1722	2066	0.833	344	4548.073207	13.221	4.438390997	2831.59		49.552825	\$219.93
010875292	1974	2413	0.818	446	25637.93762	57.484	28.30825961	578.43		10.122525	\$286.55
010881426	3003	3884	0.773	881	11672.31673	13.249	7.314987928	1033.90		18.09325	\$132.35
010898895	7422	8922	0.832	1501	28849.60694	19.220	23.23874578	635.37		11.118975	\$258.39
010914361	1378	2156	0.639	764	22512.3204	29.466	5.460586885	2747.76		48.0858	\$262.58
010931283	45614	66635	0.685	21021	758409.1003	36.079	264.2697517	134.13		2.347275	\$620.31
010931372	4011	4798	0.836	786	4941.894909	6.287	5.370571855	6318.00		110.565	\$593.80
010931468	2021	2728	0.741	707	16171.74198	22.874	6.868735441	4478.00		78.365	\$538.27
010942520	2497	3527	0.708	1035	19816.56223	19.146	7.361686922	1378.54		24.12445	\$177.60
010942577	794	847	0.937	53	1193.861746	22.526	4.81372881	1285.39		22.494325	\$108.28
010942819	1817	2271	0.800	454	7016.604455	15.455	4.878081754	814.90		14.26075	\$69.57
010992869	445	465	0.957	20	544.8923534	27.245	6.016018777	677.00		11.8475	\$71.27
010992871	746	765	0.975	19	194.3070385	10.227	6.523681232	359.54		6.29195	\$41.05
011000306	732	759	0.964	27	586.405795	21.719	7.863616601	22254.20		389.4485	\$3,062.47
011026824	2729	3529	0.773	802	18402.66394	22.946	10.70146864	2094.25		36.649375	\$392.20
011029486	592	594	0.997	2	8.88082121	4.440	4.332396122	1365.55		23.897125	\$103.53
011110558	6250	12906	0.484	6656	355200.3716	53.365	38.98876989	709.48		12.4159	\$484.08
011167167	380	380	1.000	0	0	0.000	6.475149213	1411.29		24.697575	\$159.92
011167313	15874	19065	0.833	3220	148508.6713	46.121	155.8461173	1354.32		23.7006	\$3,693.65
011172219	1476	1589	0.929	109	4773.719531	43.796	10.93897116	2120.89		37.115575	\$406.01
011175564	16951	20875	0.812	3918	189550.1957	48.379	164.6660444	2054.16		35.9478	\$5,919.38
011179931	1214	1525	0.796	311	10808.72457	34.755	6.608088306	4079.73		71.395275	\$471.79
011285343	1860	2164	0.860	304	6709.219104	22.070	7.627227137	3181.00		55.6675	\$424.59
011305743	1739	2055	0.846	316	7188.045759	22.747	7.008269475	4602.00		80.535	\$564.41
011306050	426	429	0.993	3	18.34855973	6.116	7.250144155	1538.50		26.92375	\$195.20
011306053	989	1028	0.962	39	1099.962667	28.204	9.367784237	1492.12		26.1121	\$244.61
011346899	1846	2251	0.820	405	8843.600132	21.836	7.737569529	1424.88		24.9354	\$192.94
011349738	117	117	1.000	0	0	0.000	2.816768001	3765.00		65.8875	\$185.59
011349739	4165	5142	0.810	977	16009.32734	16.386	10.40901575	4525.00		79.1875	\$824.26

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011349740	151	151	1.000	0	0	0.000	3.148010885	5856.00		102.48	\$322.61
011349756	1796	2311	0.777	515	9340.251044	18.136	5.684170742	5882.00		102.935	\$585.10
011356458	2873	3656	0.786	783	13098.88188	16.729	8.537296858	4184.00		73.22	\$625.10
011368496	1053	1359	0.775	306	3958.401381	12.936	2.711704802	1272.00		22.26	\$60.36
011380217	1362	1550	0.879	188	7563.954954	40.234	12.86482557	2494.00		43.645	\$561.49
011380224	427	440	0.970	13	280.7667182	0.000	4.79701782	570.98		9.99215	\$47.93
011428662	724	768	0.943	44	660.7922291	15.018	4.613593409	6281.25		109.921875	\$507.13
011483400	1058	1067	0.992	9	93.46688379	10.385	8.950243778	1361.31		23.822925	\$213.22
011498996	32941	52040	0.633	19023	524524.2332	27.573	161.8702554	134.13		2.347275	\$379.95
011498997	33143	44314	0.748	11124	265110.0288	23.832	153.2690227	135.06		2.36355	\$362.26
011498998	37117	45341	0.819	8352	224924.1801	26.931	212.647012	111.36		1.9488	\$414.41
011498999	23221	38450	0.604	15235	421782.0657	27.685	104.2791887	154.95		2.711625	\$282.77
011499000	29299	32644	0.898	3405	52953.39229	15.552	164.8319889	206.78		3.61865	\$596.47
011540787	1747	2155	0.811	408	4366.724841	10.703	4.265212149	652.59		11.420325	\$48.71
011688323	577	673	0.857	97	3105.653449	32.017	3.980962017	12901.90		225.78325	\$898.83
011720712	1811	2648	0.684	837	16325.99931	19.505	5.868258884	1176.45		20.587875	\$120.81
011744277	408	411	0.993	3	37.70450068	12.568	6.984947039	2160.00		37.8	\$264.03
011744278	1049	1126	0.932	77	1154.246386	14.990	7.891123476	1531.00		26.7925	\$211.42
011744279	520	520	1.000	0	0	0.000	6.279009003	1625.00		28.4375	\$178.56
011744280	516	529	0.975	13	325.357457	0.000	8.203086788	1950.00		34.125	\$279.93
011744281	783	799	0.980	16	241.4659662	15.092	6.850921275	1970.00		34.475	\$236.19
011744307	1709	2544	0.672	835	30095.85684	36.043	9.207672118	3250.00		56.875	\$523.69
011769828	949	1038	0.914	89	2231.230511	25.070	7.901764318	893.80		15.6415	\$123.60
011838164	1088	1144	0.951	56	752.563675	13.439	6.938658557	720.94		12.61645	\$87.54
011863377	716	751	0.953	35	328.9849424	9.400	5.396655465	5020.49		87.858575	\$474.14
011875033	153	153	1.000	0	0	0.000	4.95593596	1449.18		25.36065	\$125.69
011875041	1110	1412	0.786	302	7645.842658	25.317	4.5024714	32920.00		576.1	\$2,593.87
011875188	708	737	0.961	29	309.8694504	10.685	5.446075831	2177.00		38.0975	\$207.48
011893072	1301	1533	0.849	232	4536.727315	19.555	5.300438632	4698.03		82.215525	\$435.78
012034772	2115	2676	0.790	565	16911.68322	29.932	11.26734566	1674.95		29.311625	\$330.26
012050364	516	633	0.815	117	4297.502396	0.000	3.987031526	10871.24		190.2467	\$758.52
012050427	538	604	0.891	66	3647.607421	55.267	5.870157324	9889.02		173.05785	\$1,015.88
012050456	504	642	0.785	138	4858.929344	35.210	4.551689736	26105.00		456.8375	\$2,079.38
012050795	280	280	1.000	0	0	0.000	5.32424358	17700.00		309.75	\$1,649.18
012050797	708	819	0.864	111	4185.68772	37.709	5.883387093	14200.00		248.5	\$1,462.02
012050799	702	780	0.900	78	634.5203348	8.135	2.236802496	3371.80		59.0065	\$131.99
012050871	1173	1442	0.813	270	10146.53246	37.580	7.257630975	4316.00		75.53	\$548.17
012057064	3794	3795	1.000	1	0.3277928	0.328	21.67888585	19446.00		340.305	\$7,377.43
012137310	1301	1457	0.893	156	3729.993893	23.910	6.793114119	10855.00		189.9625	\$1,290.44
012186385	829	943	0.879	114	2181.316106	19.134	4.596101206	2587.00		45.2725	\$208.08
012186392	1842	2170	0.849	328	7843.1918	23.912	10.25265618	6220.00		108.85	\$1,116.00
012194678	983	1168	0.842	185	9124.579608	49.322	7.881961152	14247.80		249.3365	\$1,965.26
012201789	449	467	0.961	18	892.3952572	49.578	5.690919204	11393.67		199.389225	\$1,134.71
012294506	504	506	0.996	2	12.85715991	6.429	4.763969044	1872.00		32.76	\$156.07
012394886	1334	1881	0.709	547	9239.397443	16.891	4.557981171	25650.00		448.875	\$2,045.96

NIIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level	U/P	Repl	Hold Rt (.21/12)	Hld Cst
012411959	1543	1987	0.777	444	5499.225929	12.386	3.933338618	12124.88		212.1854	\$834.60
012479676	506	569	0.889	63	1794.043071	28.477	5.052841286	2775.00		48.5625	\$245.38
012524331	1179	1372	0.859	132	3010.384063	15.679	4.84033097	1760.00		30.8	\$149.08
012675048	940	1083	0.868	143	4569.802283	31.957	7.679491483	1500.00		26.25	\$201.59
012675068	1117	1170	0.955	53	784.6393404	14.805	7.09944597	1099.11		19.234425	\$136.55
012763958	208	208	1.000	0	0	0.000	11.04591656	4865.00		85.1375	\$940.42
012810084	623	637	0.978	14	229.0527657	16.361	7.125615316	2350.00		41.125	\$293.04
012829008	805	814	0.989	9	87.6869594	9.743	12.02408075	788.67		13.801725	\$165.95
012829115	714	716	0.997	2	25.89719485	12.949	9.745382326	676.20		11.8335	\$115.32
012858138	1668	2209	0.755	541	17620.77719	32.571	8.93043538	15400.00		269.5	\$2,406.75
012864787	1485	1926	0.771	445	15208.0961	34.175	9.553920451	5040.00		88.2	\$842.66
012864789	522	547	0.954	25	1440.481235	57.619	7.092133902	11500.00		201.25	\$1,427.29
012944162	5646	6037	0.935	391	13641.03539	34.888	78.16582966	1406.97		24.621975	\$1,924.60
013048188	871	986	0.883	115	1904.643436	16.562	4.844954252	6367.17		111.425475	\$539.85
013086683	686	812	0.845	126	4789.38142	38.011	4.474320672	5181.95		90.684125	\$405.75
013117486	14455	21682	0.667	7227	216313.6044	29.931	53.93168004	893.15		15.630125	\$842.96
013145858	508	562	0.904	54	2056.209053	38.078	4.293164113	690.56		12.0848	\$51.88
013149207	297	340	0.874	39	1425.007273	36.539	3.441768359	2701.19		47.270825	\$162.70
013178331	697	795	0.877	98	2647.936034	27.020	4.558954265	7116.00		124.53	\$567.73
013182610	2058	3025	0.680	967	28379.11924	29.348	7.566861079	12150.00		212.625	\$1,608.90
013186355	782	899	0.870	117	3409.934244	29.145	5.231164615	4140.00		72.45	\$379.00
013311678	404	467	0.865	63	2195.271362	34.846	3.433425102	7226.00		126.455	\$434.17
013382285	169	170	0.994	1	3.485044547	3.485	5.210215022	30000.00		525	\$2,735.36
013397935	782	782	1.000	0	0	0.000	12.51620294	1396.14		24.43245	\$305.80
013451504	826	1031	0.801	205	5386.652094	26.276	4.79151266	1764.00		30.87	\$147.91
013456650	119	119	1.000	0	0	0.000	3.977616967	850.00		14.875	\$59.17
013456651	105	105	1.000	0	0	0.000	1.883022635	1319.00		23.0825	\$43.46
013527033	551	704	0.783	153	4588.430351	29.990	3.613147409	26075.00		456.3125	\$1,648.72
013529965	1855	1990	0.932	135	2929.002748	21.696	20.0588973	975.00		17.0625	\$342.25
013544801	310	325	0.954	15	1434.572855	95.638	7.41590149	3150.00		55.125	\$408.80
013622920	669	758	0.883	91	2984.090631	32.792	6.73848155	5731.41		100.299675	\$675.87
013722789	414	450	0.920	36	623.7775051	17.327	3.647328503	675.00		11.8125	\$43.08
013731805	787	809	0.973	22	585.8599509	26.630	11.93455987	2382.72		41.6976	\$497.64
013731806	1207	1339	0.901	132	2721.075677	20.614	9.766890681	1550.00		27.125	\$264.93
013758841	632	655	0.965	23	668.1350731	29.049	9.102732116	6295.00		110.1625	\$1,002.78
013904835	975	1392	0.700	417	11041.28892	26.478	5.436410059	559.00		9.7825	\$53.18
013909323	653	723	0.903	70	1584.813731	22.640	5.414865704	595.00		10.4125	\$56.38
013909324	224	232	0.966	8	266.1785007	33.272	4.334558105	559.00		9.7825	\$42.40
013912116	655	767	0.854	112	2990.564225	26.701	5.064675612	559.00		9.7825	\$49.55
013914402	199	200	0.995	1	26.36523699	26.365	3.64786084	559.00		9.7825	\$35.69
013957062	750	768	0.977	18	553.0918414	30.727	8.466522289	960.00		16.8	\$142.24
013985356	19	19	1.000	0	0	0.000	3.207944016	8986.56		157.2648	\$504.50
014064382	13	13	1.000	0	0	0.000	1.211206208	2150.99		37.642325	\$45.59
014074576	39	39	1.000	0	0	0.000	2.872252714	25447.16		445.3253	\$1,279.09
014074634	815	1095	0.744	280	8511.83602	30.399	5.197940302	3591.00		62.8425	\$326.65

NIIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level	U/P Repl	Hold Rt (.21/12)	Hld Cst
014108253	121	122	0.992	1	5.865651375	0.000	2.828130604	2350.99	41.142325	\$116.36
014185119	21	21	1.000	0	0	0.000	1.788224494	596.25	10.434375	\$18.66
014221181	98	100	0.980	2	18.71970825	0.000	0.984752169	750.00	13.125	\$12.92
014225114	293	331	0.885	38	1551.500235	40.829	3.485696551	1520.00	26.6	\$92.72
014341799	87	87	1.000	0	0	0.000	2.914402356	1493.76	26.1408	\$76.18
014404503	115	116	0.991	1	8.973333358	8.973	1.922393801	544.00	9.52	\$18.30
014458185	17	17	1.000	0	0	0.000	1.558801917	6419.00	112.3325	\$175.10
014466681	24	24	1.000	0	0	0.000	2.066217709	6419.00	112.3325	\$232.10
150685523	825	982	0.840	155	3779.189827	24.382	5.216689063	2514.90	44.01075	\$229.59
150685525	10523	11765	0.894	1242	50571.42291	40.718	126.7219499	149.88	2.6229	\$332.38
150685585	5016	5947	0.843	931	19979.51163	21.460	23.91924641	5634.00	98.595	\$2,358.32
151004675	926	989	0.936	63	2751.430673	43.674	15.09487285	5450.00	95.375	\$1,439.67
151117580	640	674	0.950	34	1546.706491	45.491	14.23158694	3960.32	69.3056	\$986.33
997356301	140	142	0.986	2	26.18329443	0.000	3.939665665	2419.32	42.3381	\$166.80
997401343	913	1084	0.842	171	4794.138904	28.036	6.387139523	2929.34	51.26345	\$327.43
998919977	2012	2266	0.888	254	4811.690879	18.944	20.28433414	478.05	8.365875	\$169.70

# APPENDIX H. DATA RESULTS FROM BAND

NTIN	Issues	Dmids	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level (Per Month)	U/P Repl \$	Hold Rt (.21/12)	Hld Cst
000805166	1009	1363	0.7403	354	29113.87	82.24	23.13	3450.00	60.375	1396.7110
000805211	842	1039	0.8104	197	16428.82	83.40	19.95	3037.86	53.16255	1060.5074
001024038	502	946	0.5307	444	14205.53	31.99	2.41	2067.81	36.186675	87.1905
001053214	1141	3662	0.3116	2526	113820.72	45.06	7.32	767.94	13.43895	98.4027
001110907	694	1562	0.4443	873	16257.45	18.62	3.15	1537.80	26.9115	84.7153
001115706	915	1058	0.8648	145	4651.11	32.53	17.87	491.54	8.60195	153.7205
00112165	932	1077	0.8654	145	2824.24	19.48	7.06	1015.68	17.7744	125.4075
002185956	976	1696	0.5755	733	53406.46	72.86	5.64	6346.00	111.055	626.7666
003172349	754	893	0.8443	139	5395.24	38.81	14.15	1746.00	30.555	432.4105
004766898	1309	1722	0.7602	413	33876.79	82.03	26.04	3073.77	53.790975	1400.9801
005557358	888	1055	0.8417	168	1708.69	10.17	3.25	4134.25	72.349375	235.0044
005557414	6698	11429	0.5861	4731	158654.75	33.54	27.61	2747.76	48.0858	1327.5394
005557906	341	354	0.9633	13	317.12	24.39	4.80	11650.99	203.892325	977.9126
005759297	6359	11285	0.5635	4924	242543.61	49.26	32.56	1620.72	28.3626	923.5495
005966273	642	733	0.8759	91	969.72	10.66	3.45	2081.00	36.4175	125.5984
005966274	639	728	0.8777	86	1284.69	14.94	4.43	2084.00	36.47	161.6317
005966475	556	609	0.9130	52	1044.27	20.08	5.77	1260.59	22.060325	127.3006
006011040	525	568	0.9243	43	899.26	20.91	6.13	883.00	15.4525	94.6654
006011236	2340	3138	0.7457	792	9742.15	12.30	7.15	1947.84	34.0872	243.6502
006011294	1101	1492	0.7379	391	3891.96	9.95	4.42	484.92	8.4861	37.5241
006011365	1253	1487	0.8426	236	8347.57	35.37	16.52	1519.40	26.5895	439.2871
006011412	1923	3463	0.5553	1540	19195.57	12.46	4.73	1005.96	17.6043	83.2232
006011423	1475	2011	0.7335	536	3758.37	7.01	3.67	819.00	14.3325	52.5713
006011563	320	340	0.9412	20	454.48	22.72	5.87	1453.69	25.439575	149.2413
006026779	752	1113	0.6757	361	6807.46	18.86	3.87	2076.00	36.33	140.7566
006026786	861	1108	0.7771	247	4844.68	19.61	5.72	1559.00	27.2825	156.0510
006026815	724	1273	0.5687	551	30642.20	55.61	2.73	2517.70	44.05975	120.2589
006026823	1280	1719	0.7446	439	4935.19	11.24	4.27	1257.00	21.9975	93.9382
006026836	1742	1897	0.9183	155	1028.85	6.64	5.46	878.35	15.371125	83.9063
006137235	3010	5124	0.5874	2081	84413.08	40.56	20.39	821.23	14.371525	292.9685
006137243	862	1023	0.8426	161	9321.47	57.90	14.97	20590.72	360.3376	5394.3611
006137244	795	991	0.8022	196	4922.33	25.11	7.69	6707.00	117.3725	902.2645
006137245	2254	3269	0.6895	1015	53085.99	52.30	19.12	5165.00	90.3875	1728.4213
008707009	430	613	0.7015	181	10963.69	60.57	4.31	12213.50	213.73625	920.7040
009460294	1521	1973	0.7709	452	11212.48	24.81	10.81	1242.00	21.735	234.9744
010036797	2533	3581	0.7073	1061	55042.50	51.88	25.30	3647.77	63.835975	1615.2041
010066270	484	526	0.9202	42	729.29	17.36	6.06	9597.39	167.954325	1018.0630
010090517	605	678	0.8923	73	3024.87	41.44	16.10	649.00	11.3575	182.8249
010157346	946	1170	0.8085	224	5256.57	23.47	11.68	11450.00	200.375	2340.7796
010157451	3324	6554	0.5072	3230	230615.29	71.40	22.84	1449.36	25.3638	579.3011
010157615	917	3073	0.2984	2160	58478.01	27.07	3.51	1154.99	20.212325	70.8755
010157617	1325	1653	0.8016	328	2928.62	8.93	4.23	1378.00	24.115	101.9750
010157619	131	278	0.4712	147	3337.05	22.70	0.85	655.77	11.475975	9.7472
010166232	1196	1443	0.8288	250	3642.87	14.57	6.92	780.55	13.659625	94.5352

NIIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level (Per Month)	U/P Repl \$	Hold Rt (.21/12)	Hld Cst
010166236	476	763	0.6239	287	4979.62	17.35	2.38	720.94	0.0175	
010256020	393	621	0.6329	228	5948.34	26.09	1.95	886.74	12.61645	30.0249
010263950	1447	2623	0.5517	1176	16288.40	13.85	4.25	580.00	15.51795	30.2009
010263956	471	503	0.9364	32	622.41	19.45	5.04	871.38	10.15	43.0998
010263958	463	584	0.7928	121	2920.91	24.14	3.53	528.16	15.24915	76.8660
010263961	973	1203	0.8088	230	3884.57	16.89	4.45	871.00	9.2428	32.5815
010263963	484	530	0.9132	46	568.63	12.36	2.69	501.00	15.2425	67.7659
010300091	2316	3349	0.6915	1051	62640.88	59.60	25.83	876.49	8.7675	23.5521
010317639	892	1384	0.6445	492	12558.85	25.53	2.97	35050.00	15.338575	396.2423
010328875	662	735	0.9007	73	2187.75	29.97	10.77	2283.00	613.375	1822.1365
010329624	770	1251	0.6155	481	5363.31	11.15	2.56	539.21	39.9525	430.3399
010329693	740	900	0.8222	160	1787.22	11.17	3.08	544.90	9.436175	24.1782
010329694	567	903	0.6279	336	9195.49	27.37	2.47	2188.90	15.338575	29.3708
010337454	836	968	0.8636	132	2886.66	21.87	7.50	795.83	38.30575	94.5200
010380313	880	1040	0.8462	158	5729.29	36.26	10.49	707.95	13.927025	104.4927
010395544	5324	5955	0.8940	631	2913.48	4.62	8.71	830.00	12.389125	129.9875
010395549	758	1469	0.5160	699	23584.49	33.74	3.69	462.00	14.525	126.5251
010395551	1636	2074	0.7888	438	16151.10	36.87	13.11	889.53	8.085	29.8202
010395555	1351	1593	0.8481	242	4587.73	18.96	8.87	801.00	15.566775	204.0742
010395556	437	462	0.9459	25	485.66	19.43	6.20	544.00	14.0175	124.3244
010395580	385	587	0.6559	200	2198.23	10.99	1.60	544.35	9.52	58.9828
010395592	19427	25640	0.7577	6236	28553.77	4.58	18.20	850.00	9.526125	15.2628
010395593	1350	1605	0.8411	255	5386.67	21.12	10.12	643.00	14.875	270.7016
010400355	657	1415	0.4643	758	17582.79	23.20	2.80	950.07	11.2525	113.9019
010402651	644	823	0.7825	179	3466.82	19.37	3.14	703.24	16.626225	46.5676
010466624	473	509	0.9293	39	1883.30	48.29	14.22	6925.00	12.3067	38.6438
010466662	404	438	0.9224	34	844.98	24.85	6.63	4300.00	121.1875	1723.4282
010466666	698	914	0.7637	216	2437.76	11.29	2.59	6714.00	75.25	499.1348
010466703	528	670	0.7881	142	2636.17	18.56	2.39	905.37	117.495	304.1843
010466711	506	757	0.6684	250	7019.29	28.08	3.04	1601.54	15.843975	37.9387
010474930	556	1842	0.3018	1283	37970.87	29.60	2.19	6492.00	28.02695	85.3378
010474977	759	1192	0.6367	435	11481.81	26.39	4.01	677.16	113.61	248.3344
010474978	318	425	0.7482	107	10434.80	97.52	6.56	2059.00	11.8503	47.5039
010475007	2273	2475	0.9184	202	1182.70	5.85	5.36	617.55	36.0325	236.3816
010475018	527	1098	0.4800	571	16594.28	29.06	2.32	1238.82	10.807125	57.9376
010475020	734	871	0.8427	134	4732.49	35.32	8.36	758.20	21.67935	50.3792
010484634	391	436	0.8968	45	663.78	14.75	2.49	1564.00	13.2685	110.9581
010484647	460	585	0.7863	125	1979.40	15.84	2.48	1723.17	27.37	68.1663
010501356	795	845	0.9408	50	437.12	8.74	4.84	2034.00	30.155475	74.9240
010501361	4332	6456	0.6710	2136	24103.13	11.28	8.88	2687.00	35.595	172.3365
010501362	2573	3999	0.6434	1422	147058.10	103.42	28.33	2622.84	47.0225	417.6157
010501685	3008	4299	0.6997	1291	19109.60	14.80	8.12	2815.78	45.8997	1300.5676
010507648	466	636	0.7327	172	2417.96	14.06	1.74	1600.00	49.27615	400.3625
010515449	917	1468	0.6247	542	30294.80	55.89	5.13	3100.00	28	48.6598
									54.25	278.2576

NTIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level (Per Month)	U/P Repl \$	Hold Rt (.21/12)	Hld Cst
							28.56	1092.00	0.0175	
010521552	1277	1597	0.7996	326	23466.67	71.98	7.45	1092.00	19.11	545.7952
010543301	1160	1495	0.7759	337	8045.11	23.87	7.45	72982.00	1277.185	9517.2226
010603341	545	693	0.7864	151	4450.61	29.47	4.99	672.50	11.76875	58.6690
010603344	1531	1562	0.9802	31	116.82	3.77	5.15	537.30	9.40275	48.4160
010603348	2665	3701	0.7201	1036	9552.32	9.22	8.18	474.11	8.296925	67.8570
010624141	510	565	0.9027	55	1603.16	29.15	8.79	12228.00	213.99	1879.9294
010628605	2426	4436	0.5469	2010	29088.10	14.47	5.85	392.00	6.86	40.1593
010629351	529	559	0.9463	30	1899.23	63.31	22.51	2600.60	45.5105	1024.2399
010629365	2390	3303	0.7236	913	7694.38	8.43	6.56	539.31	9.437925	61.9282
010640485	3507	5839	0.6006	2332	122628.09	52.58	21.89	698.58	12.22515	267.6584
010658297	12492	22504	0.5551	10021	593731.06	59.25	106.04	611.71	10.704925	1135.1284
010670473	912	1235	0.7385	326	5460.40	16.75	4.07	1326.00	23.205	94.3617
010684706	648	691	0.9378	43	1463.04	34.02	11.79	4547.00	79.5725	937.9078
010685010	418	633	0.6603	215	19711.42	91.68	4.67	8571.66	150.00405	700.6394
010691903	774	870	0.8897	96	2372.95	24.72	7.24	3295.00	57.6625	417.6395
010694631	1702	2085	0.8163	383	3260.84	8.51	4.55	5464.00	95.62	434.7018
010694632	1801	2515	0.7161	718	6727.56	9.37	4.46	4691.00	82.0925	365.8159
010761346	1558	2066	0.7541	508	9468.59	18.64	6.50	2831.59	49.552825	321.9553
010875292	1459	2413	0.6046	956	81690.74	85.45	18.28	578.43	10.122525	185.0744
010881426	2619	3884	0.6743	1265	37666.40	29.78	13.14	1033.90	18.09325	237.7480
010898895	5357	8922	0.6004	3501	276069.04	78.85	36.30	635.37	11.118975	403.6731
010914361	939	2156	0.4355	1203	51526.02	42.83	3.84	2747.76	48.0858	184.7763
010931283	25100	66635	0.3767	41535	2404695.48	57.90	118.66	134.13	2.347275	278.5212
010931372	3680	4798	0.7670	1117	6976.43	6.25	5.25	6318.00	110.565	580.4534
010931468	1919	2728	0.7034	809	34710.19	42.91	15.53	4478.00	78.365	1216.9878
010942520	1874	3527	0.5313	1667	52201.22	31.31	6.10	1378.54	24.12445	147.2383
010942577	779	847	0.9197	68	1374.07	20.21	10.78	1285.39	22.494325	242.4852
010942819	1732	2271	0.7627	539	9953.06	18.47	7.10	814.90	14.26075	101.2173
010992869	435	465	0.9355	30	535.98	17.87	8.10	677.00	11.8475	95.9674
010992871	634	765	0.8288	131	2945.58	22.49	5.16	359.54	6.29195	32.4855
011000306	503	759	0.6627	259	18539.94	71.58	4.20	22254.20	389.4485	1635.7041
011026824	2426	3529	0.6874	1117	79443.66	71.12	27.18	2094.25	36.649375	996.2092
011029486	524	594	0.8822	70	944.59	13.49	2.93	1365.55	23.897125	70.0325
01110558	2920	12906	0.2263	9998	789898.84	79.01	22.80	709.48	12.4159	283.1318
011167167	249	380	0.6553	130	2627.42	20.21	0.94	1411.29	24.697575	23.2273
011167313	7044	19065	0.3695	12120	86600.78	71.50	38.16	1354.32	23.7006	904.3060
011172219	904	1589	0.5689	685	47301.88	69.05	5.68	2054.16	37.115575	210.7700
011175564	8098	20875	0.3879	12712	873033.16	68.68	53.68	2054.16	35.9478	1929.6227
011179931	1010	1525	0.6623	515	24734.84	48.03	7.25	4079.73	71.395275	517.8867
011285343	1015	2164	0.4690	1149	73043.61	63.57	3.99	3181.00	55.6675	222.2783
011305743	1527	2055	0.7431	531	18621.01	35.07	12.69	4602.00	80.535	1022.0592
011306050	386	429	0.8998	43	1854.46	43.13	11.00	1538.50	26.92375	296.1476
011306053	872	1028	0.8482	156	7335.47	47.02	18.17	1492.12	26.1121	474.4105
011346899	1370	2251	0.6086	881	53892.13	61.17	8.91	1424.88	24.9354	222.2607

NIIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level (Per Month)	U/P Repl \$	Hold Rt (.21/12)	Hld Cst
011349738	117	117	1.0000	0	0.00	0.00	7.14	3765.00	0.0175	470.1727
011349739	3564	5107	0.6979	1543	60745.64	39.37	24.05	4525.00	65.8875	1904.6800
011349740	155	155	1.0000	0	0.00	#DIV/0!	3.43	5856.00	79.1875	351.2905
011349756	1783	2272	0.7848	475	18366.82	38.67	17.20	5882.00	102.48	1770.2353
011356458	2079	3748	0.5547	1664	58894.40	35.39	8.00	4184.00	102.935	585.5339
011368496	1092	1239	0.8814	147	1912.92	13.01	4.56	1272.00	73.22	101.5122
011380217	1325	1638	0.8089	313	9419.08	30.09	16.04	2494.00	22.26	699.9183
011380224	424	455	0.9319	31	688.58	22.21	5.36	570.98	43.645	53.5448
011428662	667	790	0.8443	123	2309.41	18.78	4.83	6281.25	9.99215	531.0221
011483400	820	1088	0.7537	268	4308.26	16.08	3.16	1361.31	109.921875	75.2342
011498996	24844	50394	0.4930	2550	1023419.82	40.06	109.47	134.13	23.822925	256.9508
011498997	19332	45253	0.4272	25805	968156.60	37.52	75.12	135.06	2.347275	177.5550
011498998	18989	43129	0.4403	23965	882623.49	36.83	74.49	111.36	2.36355	145.1590
011498999	11733	36022	0.3257	24498	904265.41	36.91	47.55	154.95	1.9488	128.9427
011499000	11087	33534	0.3306	22514	829329.72	36.84	45.32	206.78	2.711625	164.0062
011540787	1580	2264	0.6979	684	7680.46	11.23	3.92	652.59	3.61865	44.7146
011688323	553	604	0.9156	55	2126.28	38.66	12.06	12901.90	11.420325	2723.1489
011720712	1239	2644	0.4686	1409	37783.80	26.82	4.43	1176.45	225.78325	91.1824
011742477	386	413	0.9346	27	476.59	17.65	5.30	2160.00	20.587875	200.4095
011744278	905	1124	0.8052	215	4571.16	21.26	6.92	1531.00	37.8	185.4263
011744279	455	526	0.8650	71	1809.13	25.48	6.23	1625.00	26.7925	177.3061
011744280	440	485	0.9072	47	1501.08	31.94	6.66	1950.00	28.4375	227.1316
011744281	726	866	0.8383	140	3528.22	25.20	6.64	1970.00	34.125	228.8827
011744307	865	2590	0.3340	1717	84982.95	49.50	5.28	3250.00	34.475	300.4769
011769828	499	922	0.5412	423	21095.51	49.87	3.55	893.80	56.875	55.5123
011838164	979	1154	0.8484	175	3468.61	19.82	6.27	720.94	15.6415	79.0958
011863377	675	764	0.8835	89	1330.53	14.95	4.82	5020.49	12.61645	423.8711
011875033	151	153	0.9869	2	16.25	0.00	4.99	1449.18	87.858575	126.4346
011875041	877	1373	0.6387	503	15368.66	30.55	4.83	32920.00	25.36065	2784.7590
011875188	594	671	0.8852	77	1704.98	22.14	6.90	2177.00	576.1	262.9309
011893072	1281	1522	0.8417	241	7855.11	32.59	18.31	4698.03	38.0975	1505.1819
012034772	1892	2761	0.6853	869	64928.02	74.72	21.66	1674.95	82.215525	634.9914
012050364	459	655	0.7008	196	14719.48	75.10	4.16	10871.24	29.311625	791.3032
012050427	397	584	0.6798	187	16348.33	87.42	4.93	9889.02	190.2467	854.0010
012050456	526	589	0.8930	63	3753.28	59.58	15.69	26105.00	173.05785	7168.5139
012050795	303	303	1.0000	0	0.00	0.00	14.71	17700.00	456.8375	4555.4591
012050797	600	880	0.6818	280	19189.21	68.53	6.69	14200.00	309.75	1662.2167
012050799	722	743	0.9717	21	142.93	6.81	3.75	3371.80	248.5	221.2969
012050871	774	1473	0.5255	706	35542.86	50.34	4.01	4316.00	59.0065	302.5728
012057064	91	3789	0.0240	3678	285689.87	77.68	2.73	19446.00	75.53	928.6505
012137310	1183	1396	0.8474	213	6784.83	31.85	17.79	10855.00	340.305	3380.1979
012186385	620	1025	0.6049	405	10361.22	25.58	2.17	2587.00	189.9625	98.3937
012186392	1699	2240	0.7585	541	39985.89	73.91	27.38	6220.00	45.2725	2979.9207
012194678	960	1154	0.8319	194	12867.42	66.33	19.68	14247.80	108.85	4907.5234

NIIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level (Per Month)	U/P Repl \$	Hold Rt (.21/12)	Hld Cst
012201789	231	422	0.5474	192	8115.55	42.27	2.23	11393.67	199.389225	445.3243
012294506	431	483	0.8923	52	500.00	9.62	2.87	1872.00	32.76	94.0962
012394886	1163	1964	0.5922	804	13684.74	17.02	4.19	25650.00	448.875	1881.7507
012411959	950	1984	0.4788	1034	18270.89	17.67	2.89	12124.88	212.1854	613.6449
012479676	439	560	0.7839	121	4900.87	40.50	3.49	2775.00	48.5625	169.2738
012524331	1169	1449	0.8068	280	4309.13	15.39	5.44	1760.00	30.8	167.4821
012675048	802	963	0.8328	168	12234.80	72.83	19.71	1500.00	26.25	517.3614
012675068	943	1052	0.8964	109	2468.73	22.65	9.85	1099.11	19.234425	189.5491
012763958	261	261	1.0000	0	0.00	0.00	79.62	4865.00	85.1375	6778.8625
012810084	568	625	0.9088	57	2259.62	39.64	12.09	2350.00	41.125	497.1430
012829008	631	725	0.8703	94	3159.44	33.61	10.48	788.67	13.801725	144.6073
012829115	676	746	0.9062	70	3029.59	43.28	14.99	676.20	11.8335	177.3440
012858138	1675	2219	0.7548	551	32024.37	58.12	19.91	15400.00	269.5	5364.8239
012864787	1420	1899	0.7478	479	36429.78	76.05	23.79	5040.00	88.2	2098.3835
012864789	489	564	0.8670	75	3806.00	50.75	15.35	11500.00	201.25	3089.5892
012944162	5338	6067	0.8798	732	15383.01	21.02	48.33	1406.97	24.621975	1189.9375
013048188	668	964	0.6929	296	9160.63	30.95	4.86	6367.17	111.425475	541.9880
013086683	682	749	0.9105	67	2742.36	40.93	13.63	5181.95	90.684125	5236.1750
013117486	8465	22378	0.3783	13913	1065453.36	76.58	37.01	893.15	15.630125	578.3975
013145858	592	672	0.8810	80	2529.09	31.61	9.77	690.56	12.0848	118.0336
013149207	349	369	0.9458	20	492.29	24.61	6.28	2701.19	47.270825	296.9332
013178331	702	785	0.8943	83	2194.71	26.44	6.50	7116.00	124.53	809.2339
013182610	2231	2991	0.7459	760	38323.87	50.43	21.88	12150.00	212.625	4652.6945
013186355	770	892	0.8632	122	5559.25	45.57	19.50	4140.00	72.45	1412.6122
013311678	386	425	0.9082	39	1601.30	41.06	10.82	7226.00	126.455	1367.6730
013328285	165	165	1.0000	0	0.00	0.00	7.64	30000.00	525	4012.7162
013397935	731	864	0.8461	133	4892.82	36.79	13.79	1396.14	24.43245	336.8687
013451504	891	1002	0.8992	111	2326.36	20.96	10.13	1764.00	30.87	312.8215
013456650	110	110	1.0000	0	0.00	0.00	7.36	850.00	14.875	109.5515
013456651	105	105	1.0000	0	0.00	0.00	4.56	1319.00	23.0825	105.2310
013527033	630	732	0.8607	102	3738.49	36.65	10.59	26075.00	456.3125	4832.7682
013529965	1560	2150	0.7256	592	19489.27	32.92	14.72	975.00	17.0625	251.1280
013544801	283	316	0.8956	33	2364.02	71.64	16.59	3150.00	55.125	914.5125
013622920	696	762	0.9134	66	2749.17	41.65	18.87	5731.41	100.299675	1892.7001
013722789	378	396	0.9545	18	465.64	25.87	5.42	675.00	11.8125	64.0640
013731805	641	737	0.8697	96	2690.91	28.03	10.83	2382.72	41.6976	451.5910
013731806	1022	1237	0.8262	215	5697.99	26.50	12.24	1550.00	27.125	332.0117
013758841	586	638	0.9185	52	1593.79	30.65	10.04	6295.00	110.1625	1105.6625
013904835	1112	1470	0.7565	358	10070.48	28.13	8.14	559.00	9.7825	79.6484
013909323	630	728	0.8654	98	2915.24	29.75	8.32	595.00	10.4125	86.6678
013909324	247	249	0.9920	2	70.16	35.08	5.66	559.00	9.7825	55.4108
013912116	699	767	0.9113	68	1884.68	27.72	10.91	559.00	9.7825	106.7117
013914402	200	204	0.9804	4	115.94	28.98	6.02	559.00	9.7825	58.9352
013957062	615	721	0.8530	106	2180.67	20.57	6.99	960.00	16.8	117.4038

NIIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level (Per Month)	U/P Repl \$	Hold Rt (.21/12)	Hld Cst
013985356	19	19	1.0000	0	0.00	0.00	5.48	8986.56	0.0175	861.9319
014064382	13	13	1.0000	0	0.00	0.00	7.02	2150.99	157.2648	264.2039
014074576	39	39	1.0000	0	0.00	0.00	6.81	25447.16	37.642325	3033.3505
014074634	916	1146	0.7993	230	5884.73	25.59	9.95	3591.00	445.3253	625.3421
014108253	122	122	1.0000	0	0.00	0.00	7.30	2350.99	62.8425	300.5388
014185119	21	21	1.0000	0	0.00	0.00	4.92	596.25	41.142325	51.3282
014221181	100	100	1.0000	0	0.00	0.00	3.42	750.00	10.434375	44.8631
014225114	324	340	0.9529	16	866.27	54.14	8.61	1520.00	13.125	229.0100
014341799	87	87	1.0000	0	0.00	0.00	5.10	1493.76	26.1408	133.2884
014404503	116	116	1.0000	0	0.00	0.00	5.90	544.00	9.52	56.2111
014458185	17	17	1.0000	0	0.00	0.00	10.36	6419.00	112.3325	1163.4776
014466681	24	24	1.0000	0	0.00	0.00	9.76	6419.00	112.3325	1096.7634
150685523	893	1054	0.8472	161	4824.91	29.97	11.19	2514.90	44.01075	492.6943
150685525	10842	11393	0.9516	551	20666.93	37.51	173.41	149.88	2.6229	454.8257
150685585	4379	5273	0.8305	894	36884.74	41.26	52.16	5634.00	98.595	5142.6990
151004675	850	850	1.0000	0	0.00	0.00	138.47	5450.00	95.375	13206.6187
151117580	711	711	1.0000	0	0.00	0.00	127.43	3960.32	69.3056	8831.4300
997356301	140	142	0.9859	2	24.05	0.00	5.97	2419.32	42.3381	252.8425
997401343	945	1073	0.8807	128	4943.17	38.62	12.70	2929.34	51.26345	650.8236
998919977	1568	2192	0.7153	627	21980.13	35.06	16.02	478.05	8.365875	133.9915

# APPENDIX I. DATA RESULTS FROM THIRD

NIIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level (Per Month)	U/P Repl \$	Hold Rt (.21/12)	Hld Cst
000805166	1150	1363	0.8437	213	22507.03	23.256	27.97	3450.00	0.0175	1688.74
000805211	875	1039	0.8422	164	15214.88	30.681	19.75	3037.86	60.38	1050.02
001024038	747	946	0.7896	199	6841.61	7.139	8.16	2067.81	53.16	295.15
001053214	2705	3662	0.7387	957	42299.14	26.302	27.50	767.94	36.19	369.53
001110907	837	1562	0.5359	730	14109.43	2.834	2.60	1537.80	13.44	69.90
001115706	940	1058	0.8885	118	4873.91	23.179	15.97	491.54	26.91	137.35
001122165	940	1077	0.8728	137	2953.40	11.580	6.78	1015.68	8.60	120.49
002185956	1389	1696	0.8190	307	26240.86	28.044	33.58	6346.00	17.77	3728.94
003172349	893	893	0.8757	111	5495.52	13.504	15.77	1746.00	111.06	3728.94
004766898	1422	1722	0.8258	300	25334.70	31.543	38.33	3073.77	30.56	481.76
005557358	888	1055	0.8417	168	1978.69	3.415	3.00	4134.25	53.79	2061.98
005557414	7160	11429	0.6265	4269	149863.96	41.735	32.80	2747.76	72.35	216.81
005557906	341	354	0.9633	13	355.82	5.663	4.44	11650.99	48.09	1576.99
005759297	7631	11285	0.6762	3654	198946.61	83.682	58.89	1620.72	203.89	905.09
005966273	632	733	0.8622	101	1451.28	3.370	3.02	2081.00	28.36	1670.18
005966274	634	728	0.8709	90	1695.87	4.523	4.06	2084.00	36.42	110.03
005966475	564	609	0.9261	44	1090.89	7.076	5.69	1260.59	36.47	148.15
006011040	527	568	0.9278	41	1003.82	5.981	6.12	883.00	22.06	125.44
006011236	2338	3138	0.7451	794	11157.07	7.753	6.56	1947.84	15.45	94.58
006011294	1098	1492	0.7359	394	4581.53	4.105	4.03	484.92	34.09	223.64
006011365	1256	1487	0.8447	237	8933.94	19.861	15.35	1519.40	8.49	34.16
006011412	1872	3463	0.5406	1591	22412.73	6.342	4.35	1005.96	26.59	408.16
006011423	1448	2011	0.7200	563	4757.26	4.241	3.37	819.00	17.60	76.65
006011563	320	340	0.9412	20	529.48	6.476	5.41	1453.69	14.33	48.30
006026779	750	1113	0.6739	363	7992.28	3.916	3.60	2076.00	25.44	137.68
006026786	859	1108	0.7753	249	5398.26	5.280	5.23	1559.00	36.33	130.65
006026815	994	1273	0.7808	280	7665.79	3.846	3.15	2517.70	27.28	142.82
006026823	1278	1719	0.7435	441	5734.21	3.873	3.96	1257.00	44.06	138.68
006026836	1741	1897	0.9178	156	1183.95	4.957	5.05	878.35	22.00	87.08
006137235	3065	5124	0.7564	1235	58839.93	35.562	35.12	821.23	15.37	77.58
006137243	828	1023	0.8094	195	12440.12	20.378	16.51	20590.72	14.37	504.67
006137244	806	991	0.8133	185	5309.01	7.862	7.46	6707.00	360.34	5947.50
006137245	2586	3269	0.7911	688	41220.34	35.769	37.29	5165.00	117.37	875.33
008707009	496	613	0.8091	117	8751.41	10.256	9.07	12213.50	90.39	3370.68
009460294	1532	1973	0.7765	441	13368.92	12.144	10.35	1242.00	213.74	1939.30
010036797	2851	3581	0.7961	730	38562.02	46.317	40.07	3647.77	21.74	224.94
010066270	477	526	0.9068	49	1328.45	7.933	5.62	9597.39	63.84	2558.20
010090517	592	678	0.8732	86	3418.10	26.149	16.19	649.00	167.95	943.60
010157346	956	1170	0.8171	214	6206.32	15.359	8.97	11450.00	11.36	183.91
010157451	4537	6554	0.6922	2017	134718.78	80.544	63.10	1449.36	200.38	1797.28
010157615	1822	3073	0.5929	1253	20764.79	7.932	5.03	1154.99	25.36	1600.50
010157617	1327	1653	0.8028	326	3460.99	4.301	3.91	1378.00	20.21	101.69
010157619	192	278	0.6906	86	1903.14	1.591	0.79	655.77	24.12	94.18
									11.48	9.04

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010166232	1181	1443	0.8184	266	4637.21	8.339	6.53	780.55	13.66	89.22
010166236	589	763	0.7720	174	3131.19	2.962	2.01	720.94	12.62	25.40
010256020	491	621	0.7907	130	2630.22	2.846	2.16	886.74	15.52	33.59
010263950	1454	2623	0.5543	1169	19111.97	4.644	4.00	580.00	10.15	40.57
010263956	464	503	0.9225	39	903.12	4.999	4.49	871.38	15.25	68.54
010263958	492	584	0.8425	92	2383.26	5.731	3.75	528.16	9.24	34.65
010263961	969	1203	0.8055	234	4664.13	5.167	4.10	871.00	15.24	62.48
010263963	485	530	0.9151	45	628.45	2.649	2.45	501.00	8.77	21.46
010300091	2602	3349	0.7769	760	50899.16	36.646	39.46	876.49	15.34	605.21
010317639	1140	1384	0.8237	244	8950.72	9.562	10.01	35050.00	613.38	6137.69
010328875	560	735	0.8980	75	2385.91	12.424	9.52	2283.00	39.95	380.23
010329624	1023	1251	0.8177	228	2503.63	2.589	2.65	539.21	9.44	25.00
010329693	737	900	0.8189	163	2210.60	3.103	2.84	544.90	9.54	27.12
010329694	734	903	0.8128	169	6135.12	8.427	5.79	2188.90	38.31	221.86
010337454	844	968	0.8719	124	3039.68	8.684	7.22	795.83	13.93	100.57
010380313	898	1040	0.8635	142	5712.68	11.531	11.10	707.95	12.39	137.55
010395544	5324	5955	0.8940	631	3096.22	9.616	8.05	830.00	14.53	116.94
010395549	1110	1469	0.7556	353	14027.34	8.193	8.53	462.00	8.09	68.97
010395551	1617	2074	0.7797	464	16228.06	14.692	14.33	889.53	15.57	223.03
010395555	1334	1593	0.8374	259	6422.43	11.547	8.81	801.00	14.02	123.46
010395556	437	462	0.9459	25	635.66	6.877	5.79	544.00	9.52	55.16
010395580	385	587	0.6559	200	2678.23	1.595	1.49	544.35	9.53	14.15
010395592	19427	25640	0.7577	6237	28723.57	28.142	16.86	850.00	14.88	250.79
010395593	1359	1605	0.8467	246	5794.79	9.820	9.21	643.00	11.25	103.65
010400355	919	1415	0.6495	496	11780.23	4.522	3.87	950.07	16.63	64.31
010402651	692	823	0.8408	131	2861.39	5.206	3.75	703.24	12.31	46.16
010466624	467	509	0.9175	46	3005.05	17.888	15.22	6925.00	121.19	1844.19
010466662	401	438	0.9155	37	1114.62	5.354	6.02	4300.00	75.25	452.78
010466666	718	914	0.7856	196	2590.11	3.023	2.44	6714.00	117.50	286.63
010466703	575	670	0.8582	95	1944.05	4.410	2.71	905.37	15.84	42.98
010466711	614	757	0.8111	143	3202.77	4.171	4.27	1601.54	28.03	119.63
010474930	1306	1842	0.7090	536	15269.80	6.950	4.92	6492.00	113.61	559.24
010474977	976	1192	0.8188	216	6967.31	8.510	6.74	677.16	11.85	79.88
010474978	354	425	0.8329	71	6769.48	7.513	7.41	2059.00	36.03	266.84
010475007	2274	2475	0.9188	201	1264.42	5.263	4.97	617.55	10.81	53.67
010475018	839	1098	0.7641	259	7261.17	8.252	4.35	1238.82	21.68	94.27
010475020	752	871	0.8634	119	5950.77	11.079	11.33	758.20	13.27	150.33
010484634	391	436	0.8968	45	723.78	2.410	2.31	1564.00	27.37	63.10
010484647	476	585	0.8137	109	1920.25	3.447	2.62	1723.17	30.16	79.01
010501356	786	845	0.9302	59	685.16	4.634	4.47	2034.00	35.60	159.06
010501361	4332	6456	0.6710	2137	25874.81	12.579	8.10	2687.00	47.02	380.84
010501362	2945	3999	0.7364	1088	111744.26	53.373	61.53	2622.84	45.90	2824.42
010501685	2978	4299	0.6927	1321	23648.40	11.945	7.54	2815.78	49.28	371.35

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010507648	513	636	0.8066	125	1853.05	1.657	1.99	1600.00	28.00	55.77
010515449	1172	1468	0.7984	297	17856.87	21.126	20.96	3100.00	54.25	1136.88
010521552	1299	1597	0.8134	299	24429.14	32.789	35.04	1092.00	19.11	669.62
010543301	1148	1495	0.7679	349	9378.93	8.044	6.72	72982.00	1277.19	8580.55
010603341	598	693	0.8629	97	1985.29	5.534	5.02	672.50	11.77	59.06
010603344	1531	1562	0.9802	31	116.82	4.362	4.76	537.30	9.40	44.75
010603348	2666	3701	0.7203	1035	10427.79	6.953	7.57	474.11	8.30	62.80
010624141	514	565	0.9097	51	1623.17	9.611	8.07	12228.00	213.99	1727.27
010628605	2414	4436	0.5442	2022	31815.76	9.210	5.41	392.00	6.86	37.11
010629351	536	559	0.9589	23	1413.18	36.360	20.98	2600.60	45.51	954.59
010629365	2388	3303	0.7230	915	8748.51	6.666	6.11	539.31	9.44	57.71
010640485	3507	5839	0.6006	2332	126672.69	70.363	20.30	698.58	12.23	248.23
010658297	16900	22504	0.7510	5604	284971.14	237.279	129.42	611.71	10.70	1385.47
010670473	913	1235	0.7393	325	6506.91	4.471	3.75	1326.00	23.21	87.06
010684706	642	691	0.9291	49	1315.53	11.102	10.25	4547.00	79.57	815.28
010685010	502	633	0.7930	131	12222.91	9.822	12.77	8571.66	150.00	1916.06
010691903	782	870	0.8989	88	2630.07	8.611	6.97	3295.00	57.66	402.10
010694631	1702	2085	0.8163	383	3791.54	3.771	4.23	5464.00	95.62	404.51
010694632	1815	2515	0.7217	705	7789.77	4.575	4.18	4691.00	82.09	342.95
010761346	1558	2066	0.7541	508	10579.49	7.969	6.05	2831.59	49.55	299.75
010875292	1837	2413	0.7613	576	50976.01	44.044	34.39	578.43	10.12	348.11
010881426	2619	3884	0.6743	1265	39875.60	19.286	12.21	1033.90	18.09	221.01
010898895	6638	8922	0.7440	2284	187709.69	133.889	99.65	635.37	11.12	1108.01
010914361	1683	2156	0.7806	454	27615.32	31.860	27.26	2747.76	48.09	1310.62
010931283	47067	66635	0.7063	19568	1175952.41	424.516	295.51	134.13	2.35	693.64
010931372	3680	4798	0.7670	1117	7645.43	6.562	4.89	6318.00	110.57	540.34
010931468	2128	2728	0.7801	600	28321.40	20.397	20.54	4478.00	78.37	1609.27
010942520	2662	3527	0.7547	865	30875.26	19.798	20.08	1378.54	24.12	484.53
010942577	766	847	0.9044	77	2220.71	12.284	9.80	1285.39	22.49	220.41
010942819	1728	2271	0.7609	543	11877.81	9.425	6.88	814.90	14.26	98.07
010982869	444	465	0.9548	21	774.52	13.489	9.48	677.00	11.85	112.36
010992871	663	765	0.8667	102	2503.85	6.087	6.88	359.54	6.29	43.28
011000306	561	759	0.7391	196	16594.84	10.450	9.88	22254.20	389.45	3848.34
011026824	2962	3529	0.8393	567	41520.05	51.870	63.28	2094.25	36.65	2319.33
011029486	524	594	0.8822	70	1079.59	2.995	2.68	1365.55	23.90	64.14
011110558	10083	12906	0.7813	2853	230121.62	102.231	84.43	709.48	12.42	1048.31
011167167	312	380	0.8211	68	1333.96	1.868	1.26	1411.29	24.70	31.20
011167313	14686	19065	0.7703	4372	302907.74	162.163	183.31	1354.32	23.70	4344.45
011172219	1229	1589	0.7734	360	24892.26	22.454	17.89	2120.89	37.12	663.81
011175564	15332	20875	0.7345	5658	389543.11	239.100	196.57	2054.16	35.95	7066.32
011179931	1215	1525	0.7967	310	16721.19	13.679	14.67	4079.73	71.40	1047.64
011285343	1655	2164	0.7648	521	39936.10	21.049	23.68	3181.00	55.67	1318.42
011305743	1608	2055	0.7825	447	17334.82	15.160	15.14	4602.00	80.54	1219.13

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011306050	387	429	0.9021	42	2364.64	14.576	10.38	1538.50	26.92	279.55
011306053	883	1028	0.8589	145	7020.08	26.015	16.26	1492.12	26.11	424.67
011346899	1764	2251	0.7837	487	27738.46	21.462	24.76	1424.88	24.94	617.49
011349738	117	117	1.0000	0	0.00	8.769	6.61	3765.00	65.89	435.35
011349739	3882	5142	0.7550	1260	58959.47	32.722	34.54	4525.00	79.19	2735.25
011349740	151	151	1.0000	0	0.00	3.324	3.14	5856.00	102.48	321.36
011349756	1845	2311	0.7984	473	19066.66	21.602	21.10	5882.00	102.94	2171.64
011356458	2731	3656	0.7470	914	32557.83	23.158	19.47	4184.00	73.22	1425.95
011368496	1157	1359	0.8514	202	2388.44	5.150	4.26	1272.00	22.26	94.88
011380217	1254	1550	0.8090	296	9622.85	22.525	12.21	2494.00	43.65	533.09
011380224	411	440	0.9341	29	576.88	6.662	5.30	570.98	9.99	52.97
011428662	622	768	0.8099	146	3603.80	5.678	4.42	6281.25	109.92	486.34
011483400	904	1067	0.8472	161	4210.19	7.892	5.27	1361.31	23.82	125.65
011498996	34839	52040	0.6695	17201	667231.56	249.438	194.44	134.13	2.35	456.40
011498997	27914	44314	0.6299	16255	551472.44	220.485	178.45	135.06	2.36	421.78
011498998	30941	45341	0.6824	14722	560672.80	228.908	207.20	111.36	1.95	403.80
011498999	24599	38450	0.6398	13851	492877.08	201.603	143.78	154.95	2.71	389.88
011499000	21008	32644	0.6435	11851	426414.23	156.404	135.73	206.78	3.62	491.15
011540787	1487	2155	0.6900	668	8724.14	4.118	3.63	652.59	11.42	41.45
011683323	603	673	0.8960	74	3678.21	13.364	13.42	12901.90	225.78	3030.19
011720712	1908	2648	0.7205	740	21019.32	11.385	10.66	1176.45	20.59	219.54
011744277	385	411	0.9367	26	826.41	5.173	4.80	2160.00	37.80	181.55
011744278	876	1126	0.7780	250	7677.07	9.541	8.26	1531.00	26.79	221.31
011744279	461	520	0.8865	59	1495.64	6.322	5.93	1625.00	28.44	168.72
011744280	482	529	0.9112	47	1860.05	6.432	6.38	1950.00	34.13	217.60
011744281	685	799	0.8573	114	2825.72	6.596	6.16	1970.00	34.48	212.22
011744307	1961	2544	0.7708	583	29243.54	17.010	20.94	3250.00	56.88	1190.76
011769828	831	1038	0.8006	207	10154.85	8.005	8.23	893.80	15.64	128.78
011838164	960	1144	0.8392	184	4102.92	7.162	5.87	720.94	12.62	74.06
011863377	649	751	0.8642	102	1490.09	4.636	3.76	5020.49	87.86	330.72
011875033	151	153	0.9869	2	16.25	4.892	4.62	1449.18	25.36	117.07
011875041	1067	1412	0.7557	345	12370.72	9.341	9.31	32920.00	576.10	5363.10
011875188	651	737	0.8833	86	1980.66	6.828	6.75	2177.00	38.10	257.11
011893072	1316	1533	0.8584	217	8268.93	15.681	15.55	4698.03	82.22	1278.63
012034772	2121	2676	0.7926	555	40616.28	34.863	41.63	1674.95	29.31	1220.27
012050364	504	633	0.7962	129	10781.49	9.688	7.39	10871.24	190.25	1405.82
012050427	502	604	0.8311	102	7880.45	6.126	8.33	9889.02	173.06	1441.12
012050456	573	642	0.8925	69	4399.95	16.384	20.25	26105.00	456.84	9251.45
012050795	280	280	1.0000	0	0.00	11.840	10.25	17700.00	309.75	3176.29
012050797	673	819	0.8217	156	12098.31	14.846	13.23	14200.00	248.50	3287.35
012050799	0	780	0.0000	777	21230.59	3.457	0.80	3371.80	59.01	47.39
012050871	1095	1442	0.7594	347	24962.89	26.169	16.52	4316.00	75.53	1248.03
012057064	2813	3795	0.7412	982	25414.65	17.042	13.10	19446.00	340.31	4458.77

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012137310	1263	1457	0.8668	194	8312.65	21.272	18.26	10855.00	0.0175	3468.49
012186385	768	943	0.8144	175	5093.97	6.603	5.56	2587.00	45.27	251.84
012186392	1742	2170	0.8028	428	28920.51	45.153	33.34	6220.00	108.85	3628.85
012194678	950	1168	0.8134	218	17411.59	23.802	20.02	14247.80	249.34	4992.96
012201789	382	467	0.8180	85	5074.08	7.403	4.82	11393.67	199.39	960.44
012294506	463	506	0.9150	43	458.47	2.687	2.44	1872.00	32.76	79.81
012339486	1406	1881	0.7475	475	9040.41	7.581	5.76	25650.00	448.88	2584.20
012411959	1324	1987	0.6663	663	11257.50	5.485	3.88	12124.88	212.19	822.26
012479676	469	569	0.8243	100	3709.96	7.906	4.81	2775.00	48.56	233.45
012524331	1128	1372	0.8222	244	4210.62	5.386	5.32	1760.00	30.80	163.72
012675048	866	1083	0.7996	223	16838.52	23.194	18.95	1500.00	26.25	497.51
012675068	1052	1170	0.8991	118	3250.28	10.686	8.79	1099.11	19.23	169.10
012763958	208	208	1.0000	0	0.00	72.986	15.41	4865.00	85.14	1311.72
012810084	581	637	0.9121	56	2596.40	15.740	12.16	2350.00	41.13	500.28
012829008	730	814	0.8968	84	2856.86	9.270	9.64	788.67	13.80	132.99
012829115	639	716	0.8925	77	3358.65	13.865	11.83	676.20	11.83	139.97
012858138	1766	2209	0.7995	443	27543.75	34.180	28.11	15400.00	269.50	7574.35
012864787	1510	1926	0.7840	416	37092.70	33.599	30.45	5040.00	88.20	2685.99
012864789	484	547	0.8848	63	4832.99	17.767	16.76	11500.00	201.25	3372.20
012944162	5414	6037	0.8968	623	12286.26	100.684	48.86	1406.97	24.62	1202.97
013048188	769	986	0.7799	217	6425.06	7.492	5.73	6367.17	111.43	638.94
013086683	706	812	0.8695	106	3565.32	16.626	14.04	5181.95	90.68	1273.31
013117486	16545	21682	0.7631	5137	482409.65	349.143	95.24	893.15	15.63	1488.55
013145858	513	562	0.9128	49	1741.83	11.489	10.04	690.56	12.08	121.39
013149207	311	340	0.9147	29	704.30	7.020	5.86	2701.19	47.27	277.23
013178331	717	795	0.9019	78	2279.65	8.531	7.28	7116.00	124.53	906.07
013182610	2313	3025	0.7646	716	31169.95	37.196	26.66	12150.00	212.63	5668.05
013186355	786	899	0.8743	113	6531.08	21.965	15.66	4140.00	72.45	1134.70
013311678	426	467	0.9122	41	2472.54	12.143	14.98	7226.00	126.46	1893.72
013382285	169	170	0.9941	1	77.10	10.174	7.81	30000.00	525.00	4098.48
013397935	694	782	0.8875	88	4359.86	13.574	11.88	1396.14	24.43	290.16
013451504	924	1031	0.8962	107	3164.59	11.087	9.11	1764.00	30.87	281.22
013456650	119	119	1.0000	0	0.00	8.888	6.12	850.00	14.88	91.04
013456651	105	105	1.0000	0	0.00	4.775	4.81	1319.00	23.08	111.03
013527033	622	704	0.8835	82	3073.61	11.944	9.00	26075.00	456.31	4108.23
013529965	1646	1990	0.8271	344	12634.04	22.421	14.95	975.00	17.06	255.13
013544801	298	325	0.9169	27	3148.85	13.086	16.36	3150.00	55.13	901.81
013622920	684	758	0.9024	74	4134.69	19.028	20.62	5731.41	100.30	2067.90
013722789	414	450	0.9200	36	1010.69	7.151	5.91	675.00	11.81	69.86
013731805	705	809	0.8714	104	2811.39	9.520	8.74	2382.72	41.70	364.44
013731806	1090	1339	0.8140	249	7885.81	14.798	12.48	1550.00	27.13	338.43
013758841	597	655	0.9115	58	1925.11	11.392	8.86	6295.00	110.16	976.32
013904835	1087	1392	0.7809	301	9144.20	13.607	8.11	559.00	9.78	79.31

NIIN	Issues	Dmds	SMA	B/O's	Time in B/O	Avg Time	Avg Inv Level (Per Month)	U/P Repl \$	Hold Rt (.21/12)	Hld Cst
013909323	630	723	0.8714	93	3162.68	10.674	8.43	595.00	0.0175	87.73
013909324	225	232	0.9698	7	193.09	8.150	5.92	559.00	10.41	57.95
013912116	680	767	0.8866	87	3072.94	14.740	10.67	559.00	9.78	104.35
013914402	198	200	0.9900	2	86.66	8.125	5.87	559.00	9.78	57.39
013957062	678	768	0.8828	90	2555.63	12.931	5.75	960.00	16.80	96.58
013985356	19	19	1.0000	0	0.00	5.859	5.07	8986.56	157.26	798.09
014064382	13	13	1.0000	0	0.00	6.309	6.50	2150.99	37.64	244.63
014074576	39	39	1.0000	0	0.00	5.314	6.31	25447.16	445.33	2808.66
014074634	922	1095	0.8420	173	6049.41	12.836	10.94	3591.00	62.84	687.58
014108253	122	122	1.0000	0	0.00	5.949	6.75	2350.99	41.14	277.84
014185119	21	21	1.0000	0	0.00	5.678	4.55	596.25	10.43	47.53
014221181	100	100	1.0000	0	0.00	3.240	3.13	750.00	13.13	41.08
014225114	309	331	0.9335	22	1002.65	11.086	7.76	1520.00	26.60	206.30
014341799	87	87	1.0000	0	0.00	4.680	4.37	1493.76	26.14	114.29
014404503	116	116	1.0000	0	0.00	4.572	5.47	544.00	9.52	52.05
014458185	17	17	1.0000	0	0.00	9.043	9.59	6419.00	112.33	1077.29
014466681	24	24	1.0000	0	0.00	9.043	9.04	6419.00	112.33	1015.52
150685523	865	982	0.8809	112	3966.28	17.066	9.34	2514.90	44.01	411.16
150685525	10274	11765	0.8733	1536	58928.92	212.966	105.34	149.88	2.62	276.29
150685585	4752	5947	0.7991	1187	41747.57	55.173	41.16	5634.00	98.60	4058.09
151004675	989	989	1.0000	0	0.00	163.822	86.75	5450.00	95.38	8273.44
151117580	674	674	1.0000	0	0.00	157.156	70.77	3960.32	69.31	4904.53
997356301	140	142	0.9859	2	24.05	4.882	5.53	2419.32	42.34	233.97
997401343	943	1084	0.8699	141	5677.92	12.600	13.86	2929.34	51.26	710.29
998919977	1800	2266	0.7944	466	17698.84	20.345	19.53	478.05	8.37	163.38

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